The Milbank Memorial Fund

QUARTERLY

CONTENTS

Vol. XXIV OCTOBER 1946 No. 4

Edited by the Technical Staff

Published quarterly by the MILBANK MEMORIAL FUND, 40 Wall Street, New York 5, New York. Printed in the U. S. A. Subscription: $1.00 a year.

F
stopp
hom
befo
acco
D. J.
land
of al
fairly
prot
adva
land
were
This
suffe

Th
by th
Con
fluct
diur
kins
tion
pers
gm.
high
duri

IN THIS ISSUE

For nearly five years the Netherlands was occupied by the Germans and all import and export trade with the rest of the world was stopped. This densely populated country became dependent entirely upon home-produced food supplies, except for some food stocks accumulated before the war through the foresight of her government. A detailed account of how this situation was met is given by Dr. M. J. L. Dols and D. J. A. M. van Archen in "Food Supply and Nutrition in the Netherlands During and Immediately After World War II." By strict control of all available foods and planned production, it was possible to provide fairly adequate amounts of calories until 1944, but a shortage of fats and protein led to a gradual shift to high carbohydrate diets. After the Allied advance in Europe in 1944 had cut off Western from Eastern Netherlands, food distribution was disrupted completely, and starvation diets were the common lot of the urban populations of Western Holland. This critical period caused the death of many persons and many others suffered from severe nutritional diseases.

• • •

The interpretation of any observed hemoglobin value is made difficult by the fact that the hemoglobin content of the blood is very unstable. Considerable variation within one day has been reported, as well as large fluctuations from day to day. For a large number of persons, data on diurnal changes in hemoglobin have been collected by Dr. Walter Wilkins and Ruth Blakely who present these data in "Preliminary Observations on Diurnal and Other Variations in Hemoglobin Levels." For 651 persons, mostly school children, morning values were on the average 0.6 gm. higher than afternoon values, and 83 per cent of the subjects had higher values in the morning. For twenty-one girls examined five times during one day, highest values were obtained in the morning, lowest

values between two and five in the afternoon, and in the evening the values increased but continued lower than morning values. Determinations made before and after strenuous exercise for 144 boys gave higher values after exercise.

• • •

The effect of prolonged iron therapy on the hemoglobin levels of a small group of women who were found to have slightly subnormal values at one examination is reported in "Hemoglobin Variations for Women on Iron Therapy for Thirty-One Months" by Dorothy G. Wiehl and Dr. H. D. Kruse. For comparison, hemoglobin values were observed over the same period for other women with low values and for some with normal average values and with higher than average values. Three months after therapy was begun, the average hemoglobin levels for the therapy group and for the low hemoglobin nontherapy group were somewhat higher than at the first examination; but both groups showed the same increase, and continued to be alike throughout the remaining twenty-eight months. Neither the therapy nor the nontherapy group reached an average level at any time equal to the average for women with higher initial values.

• • •

The economic development of British South Africa, and especially of the Union, has been largely contingent upon the utilization of unskilled native labor. Yet social and territorial segregation has prevented the development of a permanent industrial labor force. Rather, natives are recruited on a temporary basis for work in the principal labor centers. In a paper "The Migration of Native Laborers in South Africa" Dr. Wilbert E. Moore indicates the approximate amount and turnover of the migratory labor drawn from predominantly native areas within the Union and from beyond the national borders. This migratory movement is interpreted in terms of the peculiar institutional conditions that require such a labor system.

FOOD SUPPLY AND NUTRITION IN THE NETHERLANDS DURING AND IMMEDIATELY AFTER WORLD WAR II[1]

M. J. L. Dols, M.D. and D. J. A. M. van Arcken

Introduction

ONE of the most important social problems both from a health and from an economic point of view is the public health. This is readily seen from the fact that impaired health goes hand in hand with an increase in the rate of illness by which the economic production of a nation is reduced, whereas, in the opposite case, good health can enlarge the labor achievements and consequently the economic output.

It may be accepted now as a generally known fact that good and sufficient nutrition is one of the most important factors for the maintenance and promotion of public health. Those who may doubt on this point may be referred to the consequences of malnutrition in a large part of the world and of undernutrition in the various countries during the German occupation.

Good and sufficient nutrition, however, can be maintained only if the country itself can produce the necessary food or if it is able to supplement its domestic production to the required level and to the desirable composition (Jansen) (1).

These facts apply not only under normal conditions but also during a war or occupation of a country. Therefore, a brief history of the nutrition of the Dutch people during the second World War is of interest not only to those who were living in the Netherlands during the German occupation, but also to many others abroad, who have followed our fight against starvation from a great distance.

Many people in our densely populated country lost their lives

[1] From the Ministry of Agriculture, Fisheries and Food, The Hague Food Division.

in this struggle against famine; many others undoubtedly have had their health impaired. Nevertheless, during these very difficult years the Dutch food authorities did all they could to prevent total starvation with its serious consequences.

In this report we have no intention to defend the work of the department of Food Supply during the occupation nor to argue the correctness of any policy followed. The purpose of this report is only to tell the general reader and the nutritionists, medical and public health people, physiologists, economists, and agriculturists especially about the food supply, production and imports before the war and also about the serious difficulties with the food supply of the Dutch people during the German occupation. Furthermore, some of the most important facts which have determined the policy of the Dutch food authorities in that time will be discussed.

Also, there will be presented data on the Dutch production, export, rationing and distribution of food during the occupation which are of great importance for the nutritionists in our country as well as abroad.

Prewar Consumption

It may be considered a matter of common knowledge that nutrition in the Netherlands in prewar days was on a high level, not only as regards the per capita consumption of calories but also with respect to meal patterns and quality (2). The fact, however, that the Netherlands was largely dependent for its food supply upon imports of foodstuffs or raw materials is less generally known, and even now it is not always fully realized.

This dependence applies not only to grains for bread and to fats but also to feed for livestock. The latter products are converted by fowls and livestock into highly valuable foodstuffs (butter, cheese, meat, milk, eggs), an appreciable portion of which would be exported.

Tables 1 and 2 give the import and export figures for the most

Table 1. Prewar production and imports of foodstuffs in the Netherlands. In gross tons, yearly figures, or annual averages.

Product	Imports 1935-36 1937-38	Production 1934-38	Imports[1] 1938-39	Production[1] 1938-39	Imports[1] 1939-40	Production[1] 1939-40
Cereals						
Wheat	538,000	389,000	701,000	417,000	705,000	400,000
Rye	9,000	517,000	29,000	603,000	32,000	420,000
Barley	233,000	138,000	178,000	146,000	201,000	146,000
Oats	9,000	412,000	40,000	449,000	55,000	326,000
Corn	939,000	1,000	777,000	1,000	624,000	2,000
Flour (Grain)	52,000	—	90,000	—	98,000	—
Total	1,780,000	1,457,000	1,815,000	1,616,000	1,715,000	1,294,000
Oil Seeds						
Linseed			292,000	16,000	303,000	22,000
Ground Nuts			178,000	—	192,000	—
Palmkernels			49,000	—	46,000	—
Soya Beans			110,000	—	119,000	—
Copra			53,000	—	76,000	—
Rape Seed			2,000	6,000	3,000	—
Sesam Seed			6,000	—	6,000	—
Other Oil Seeds			66,000	9,000	63,000	9,000
Total			756,000	31,000	808,000	31,000
Oil Cakes						
From Oilseeds as Above			417,000		448,000	
Cattle Cake Imported as Cakes			177,000		191,000	
Total			594,000		639,000	
Oils and Fats						
Quantity from Imported Seed (Including Linseed Oil), Whale-Oil and Vegetable Oil for Human Consumption			162,000		208,000	

[1]For oil seeds and oil cakes, data are for the calendar years 1938 and 1939.

Product	Production 1938	Exports 1938	Production 1939	Exports 1939
Butter	101,000	52,000	109,000	56,000
Cheese	126,000	58,000	121,000	52,000
Milk	5,146,000	—	5,412,000	—
Milk Products	171,000	187,000	164,000	184,000
Meat (on the Hook)	361,000	32,000	411,000	42,000
Eggs (in Millions)	2,250	1,150	2,450	1,375

Table 2. The Netherlands as an export country before the war. (Amounts in gross tons).

important foodstuffs during years previous to 1940. The average production figures of Dutch crops in a few prewar years have been inserted for comparison in Table 1 in order to stress the volume of imports. The aggregate Dutch production of various foodstuffs and the export figures for the same years are compared in Table 2.

Immediately after the outbreak of the war in August, 1939, the importation of foodstuffs became extremely difficult and stopped altogether during the German domination. From May 15, 1940, the Netherlands was entirely dependent for its food supply upon the stocks of foodstuffs and raw materials on hand at the time and upon the home production. The stocks of the most important products on hand on May 15, 1940, are shown in Table 3.

Moreover, under compulsion from the German occupation

Table 3. Stocks of the most important foodstuffs on May 15, 1940.

Product	Number of Tons	Product	Number of Tons
Wheat	450,000	Sugar	95,400
Rye	166,500	Butter	3,600
Barley	252,000	Cheese	16,500
Oats	122,800	Edible Oils and Fats	130,700
Pulses	79,000	Oil Seeds	111,300
Potato Starch	24,400	Cattle Cakes	85,300

authorities, appreciable quantities of food products were supplied to the occupation forces and additional large quantities were exported, with or without imports to be supplied in exchange. A summary of these quantities expressed in terms of hectares of cultivated land is given in Table 4. The total area of cultivated land in the Netherlands amounts to some 2,300,000 hectares. In the four and one-third years from May, 1940 to September, 1944, the output of about 60 per cent of our cultivated land was exported.

For the period September, 1944 until the end of the war no reliable data are available.

Because of the loss of imports, agriculture had to be adapted to new circumstances. This adjustment consisted in an appreciable reduction in our pig and poultry population. Both pigs and poultry are the rivals of man as regards the consumption of cereals, and if this reduction had not been carried out, both the total production of home-grown grain and the stocks on hand would have been consumed by these animals.

In addition, the production of foodstuffs had to be increased

Table 4. Compulsory Dutch exports during the war and supplies to German military forces expressed in terms of hectares of cultivated land, from May, 1940 until September, 1944.

Product	Net Exports (Hectares)	Supplies to German Forces in the Netherlands (Ha.)
Arable Crops	135,000	108,000
Dairy Products	190,000	67,000
Margarine, Fat and Oil (Fatty Acids Included)	107,000	15,000
Meat and Meat Products	267,000	208,000
Horticultural Products	115,000	14,000
Eggs and Poultry	97,000	19,000
Fish	19,000	7,000
Total (General 1,368,000)[1]	930,000	438,000

[1]One hectare is 2.47 acres.

as much as possible. This could be achieved by promoting the cultivation of a few crops essential for our nutrition. One instance of this was the stimulation of potato growing, the prewar acreage of 130,000 hectares being raised to 210,000 hectares in 1943. The acreage under rape seed was increased from 3,000 hectares in prewar years to some 50,000 hectares in 1943, and the acreage under rye was increased from 110,000 hectares to 300,000 hectares (more recent figures are less fit for comparison, since many areas had been inundated). In order to make these adjustments, part of the grass lands had to be broken up and the growing of a few crops of minor importance had to be restricted. Only in this way was it possible to raise the production of home-grown crops to a level at which starvation need not necessarily be feared, in spite of the fact that the importation of foodstuffs had become impossible and local stocks were nearly exhausted.

Table 5. Annual use of fertilizers in kilograms per hectare of cultivated land.

Year	N	P_2O_5	K_2O
1935-1938 (Average)	32.5	56.0	50.5
1939-1940	39.9	39.1	46.9
1940-1941	36.0	21.3	60.3
1941-1942	26.7	4.0	53.1
1942-1943	23.5	2.3	55.3
1943-1944	19.0	2.0	48.2
1944-1945	9.1	0.6	30.3
1945-1946[1]	27.7	21.5	23.1

[1]Estimation.

Calculations had shown that under the most favorable circumstances, *i. e.,* with sufficient fertilizers at our disposal, and an ideal crop plan, the Dutch soil might supply an average of 2,000 calories per capita per day. This figure should be borne in mind in connection with the rationing policies which will be dealt with presently.

As regards the fertilizer supply, this remained well below the prewar level, as appears from data in Table 5. Importation of synthetic fertilizer was stopped, and the country became dependent on manure for fertilizer. The quality of manure is necessarily closely connected with the feeding of the cattle and thus is on

the one hand dependent upon the application of fertilizers to meadows and pastures, and on the other hand upon the quantity of concentrated fodder.

From calculations by Van der Meulen (3) it appears that the quantity of fertilizers imported in 1938 yielded an amount of nitrogen almost equal to that obtained from the manure used in prewar times when cattle received a good feeding of concentrates. Other elements needed as fertilizer, normally were supplied largely by artificial fertilizer, manure being a relatively unimportant source which, nevertheless, during the war was not a negligible factor in its effect on the fertility of our cultivated land.

The consequences of the shortage of fertilizers manifested themselves in a decline of the production figures, as appears from Table 6.

It is needless to say that the total stoppage of the importation of concentrated fodder and the insufficient dunging of pastures and meadows greatly affected the production of meat and dairy products. Some figures on the milk supply to dairies, which are shown in Figure 1, convey an idea of the extent of this effect.

It stands to reason that the quality of the war rations, which were entirely home-produced, was inferior to that of prewar rations. They contained more carbohydrates but fewer proteins and fats. This, too, clearly appears from the graphs attached.

Table 6. Exhaustion of the Dutch soil as a consequence of war.

Product	Estimated Production Per Hectare Expressed in Terms of Kilograms[1]				
	1940	1941	1942	1943	1945
Cereals	2,514	2,237	2,117	2,098	1,449
Pulses	2,425	2,097	1,630	1,817	1,864
Potatoes and Sugarbeet	21,859	21,546	21,506	19,822	15,044

[1]On account of the war no data are available for 1944.

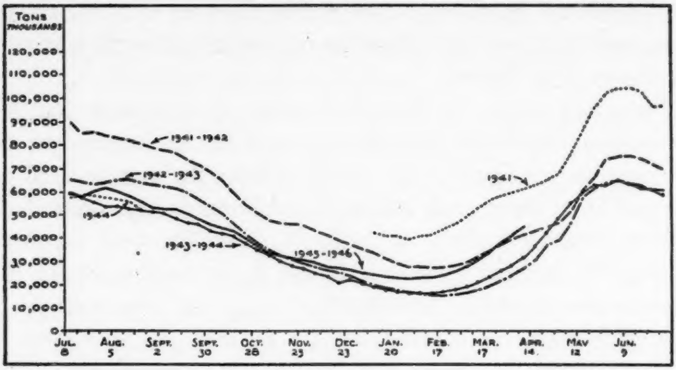

Fig. 1. Weekly deliveries of milk at dairies by live-stock farmers in the Netherlands, January 5, 1941 — April 13, 1946. (August 27, 1944 to July 7, 1945 not available.)

RATIONING

When a second European war threatened to break out, the then Minister of Economic Affairs decided in 1937 to establish the Government Office for the Preparation of the Food Supply in Time of War. This office was charged with making the necessary preparations for the economic warfare in the field of the food supply for the Dutch people, for such time as the Netherlands would be neutral or the Dutch territory in Europe would be partly or wholly occupied, as might be the case.

The existing organization, based on the Agricultural Crisis Act of 1933, participated in this preparatory work. By September, 1938, nine economic emergency acts had already come into force, among which were the soil-production act and the rationing act.

Thus, when war broke out in August, 1939, the machinery was ready to be put into operation. One of the first measures taken in the Netherlands was the introduction of a rationing scheme for animal feed, aimed at the most economical consumption of feed stocks on hand at the time.

Immediately after the occupation of the Netherlands by the Nazis on May 15, 1940, measures were taken for the distribution of all human foods, the object of which was to maintain the food supply on as high a level as possible under the circumstances and thus prevent the health of the Dutch people from being affected beyond repair. These preparations had started as far back as 1939. The population was divided into age groups; each group was entitled to a ration which covered its requirements as much as possible, both as regards quality and quantity. In addition to this classification according to age, a second was made according to classes of labor. Workers on heavy and very heavy work as well as those on long-time or night jobs were entitled to extra rations. Supplementary rations were also given to persons employed on work considered injurious to health and special regulations were made for sick persons and expectant and nursing mothers.

Besides this rationing, which was based on ration books and coupons, there was the Communal Kitchen system. Originally only those people got meals from the Communal Kitchen who, either for economic, social, or financial reasons, were not able to cook their own meals. To partake of these meals it was necessary to hand in part of the current coupons; however, the food value of these meals was much greater than was represented by the coupons thus handed in.

Moreover, from 1941 large groups of workmen were entitled to a coupon-free meal from these Kitchens. The food value of these meals amounted to some 600 calories per three-quarter litres per day. In this way approximately 450,000 workers got an extra meal daily, these meals being supplied by 140 Communal Kitchens throughout the country.

In addition to these groups of persons who were entitled to an extra meal over and above their normal rations, large groups of school children received extra food. Also, the distribution of milk in the schools was continued during the first few years of

the war. Later on these extra supplies had to be stopped on account of lack of milk. Even in prewar days, school children in several large towns were provided with food in various forms. The object was to provide children of the poorest classes with meals. When rationing regulations took effect, care was taken that children's rations never fell below the physiological standard, and coupons had to be taken from such children as partook of these meals. On account of this regulation their number declined. The parents simply could not be talked into delivering coupons for this purpose. In many places these meals, which were organized by municipalities and school boards, had to be stopped. In order to improve this situation, it was decided on February 1, 1942 to provide the children with a full meal from the Communal Kitchen and these meals were supplied coupon-free. Originally only children of the poorest classes were entitled to such meals, but in 1943 the basis of participation was altered. From that date onward, in addition to the children referred to above, all children were entitled to a meal who, according to the school doctor, were 20 per cent below normal weight. The inclusion of a National Socialist organization by the German authorities, which was vainly protested by the Government Office for Food Supply, caused attendance to be very small.

Besides children of the elementary schools, pupils of secondary and technical schools and those in the universities also were entitled to a daily coupon-free meal.

The numbers of persons who were supplied with meals by the Communal Kitchens during the period from March, 1942 to August, 1944 are shown in Figure 2.

Besides the rationing of food, the provision of vitamins to some important groups was undertaken. In the first place, expectant and nursing mothers and the school children were provided with vitamin C tablets. Later on, by order of the occupation forces, these tablets were distributed also among the work-

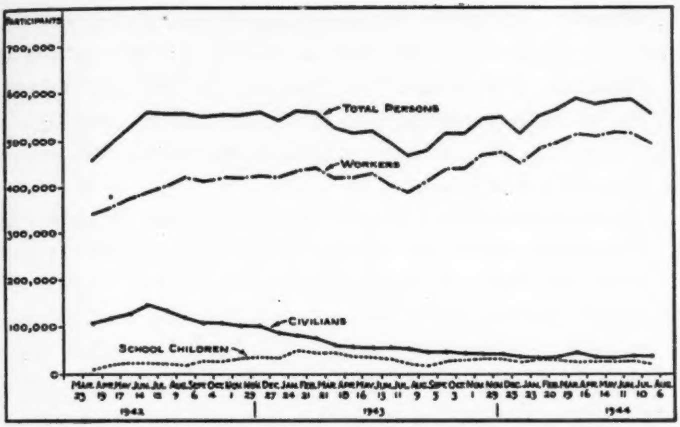

Fig. 2. Average daily number of persons served at Communal Kitchens in the Netherlands by four-week periods from March 23, 1942 to August 6, 1944.

men. They were supplied during a period beginning early in March until May 15th or thereabouts. During the winter months vitamin D tablets also were distributed among babies and very young children. The importance of supplying these vitamins will be discussed later.

In addition to giving these vitamin preparations, oranges and mandarins also were distributed sometimes among the children, and carotene preparations and fresh carrots were issued to the children over and above their normal rations.

Committees

Even previous to May 10, 1940, by mutual agreement, the Public Health Division of the Department of Social Affairs, the Department of Economic Affairs, and the Government Office for the Preparation of the Food Supply in Time of War had reached an understanding concerning the formation of a Food Council. The outbreak of the war caused this Council to be formed not as an independent body but as a Committee of the Health Council. Throughout the war this Food Council assisted

the Director General for the Food Supply in his task and undoubtedly did much useful work on its own initiative as well as on request. It also brought into existence the Advisory Bureau, which materially contributed to the solution of the many problems regarding the numerous rationing regulations with which the housewife was faced.

A special subcommittee of the Food Council was charged with the compilation of the "Regulations Regarding the Rationing of Food for Sick Persons," and another subcommittee studied the correlation between the rations and public health. The activities of the latter subcommittee, the so-called Pouls Committee, were broken off by the railroad strike, but after the liberation immediately were taken up again with the cooperation of American and English research workers. A report of the results of this research work will be released in due course.

In addition to these activities of the subcommittees, the Food Council encouraged scientific research into many subjects. This research was carried out mainly by "Het Nederlandsche Instituut voor Volksvoeding" (the Netherlands Institute for National Nutrition) and "Het Centraal Instituut voor Voedingsonderzoek C.I.V.O. (the Central Institute for Food Research). As examples, the research work concerning the milling extraction of grains for bread and the preparation of synthetic vitamin C may be mentioned.

Food Rations

The food rations distributed throughout the Netherlands by weeks from April 27, 1941 until October 1, 1944 are shown in Figures 3 to 10 inclusive in terms of the average daily calories furnished and the average daily grams of protein, carbohydrate, and fat. For each of these four food values, the content of the rations is given according to age groups, *viz.,* 0-3 years, 4-13 years, 14-20 years, and 21 years and over, or adults classified as

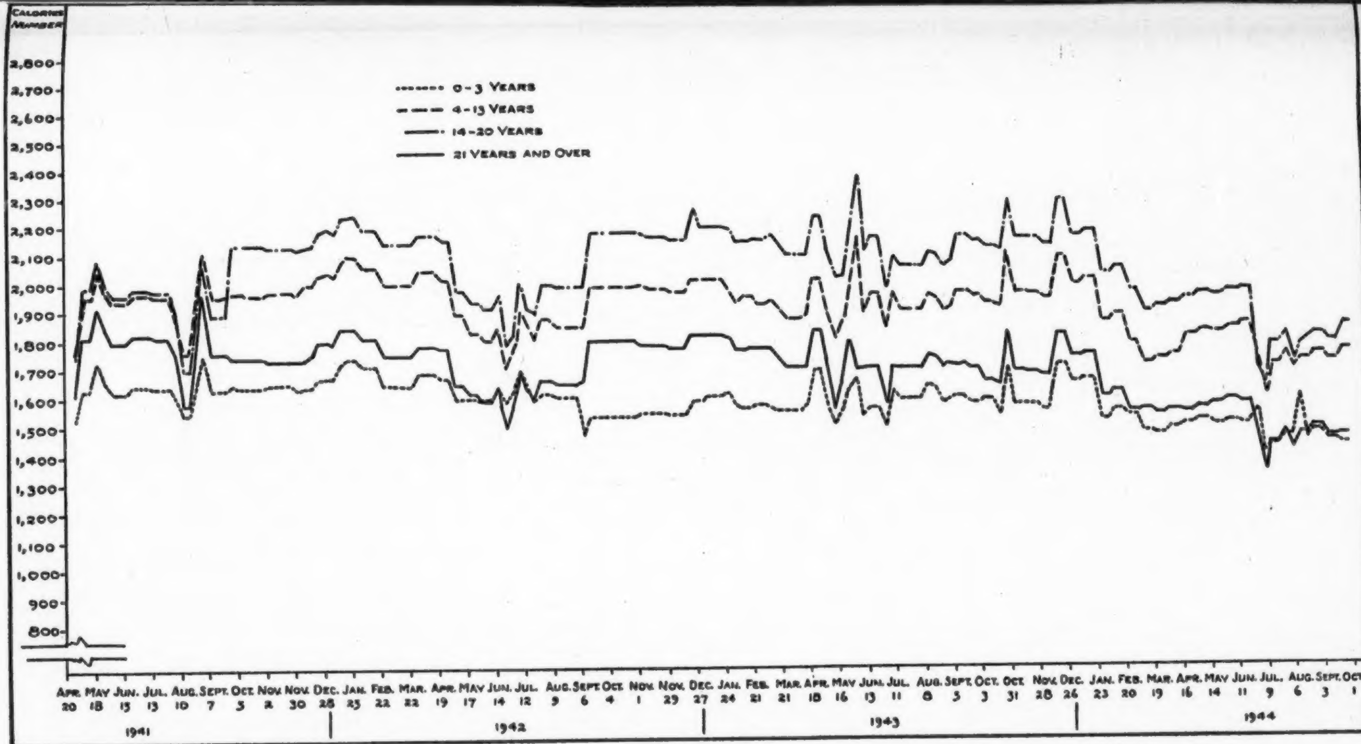

Fig. 3. Calories per day in weekly food rations distributed throughout the Netherlands to different age groups from April 27, 1941 to October 1, 1944.

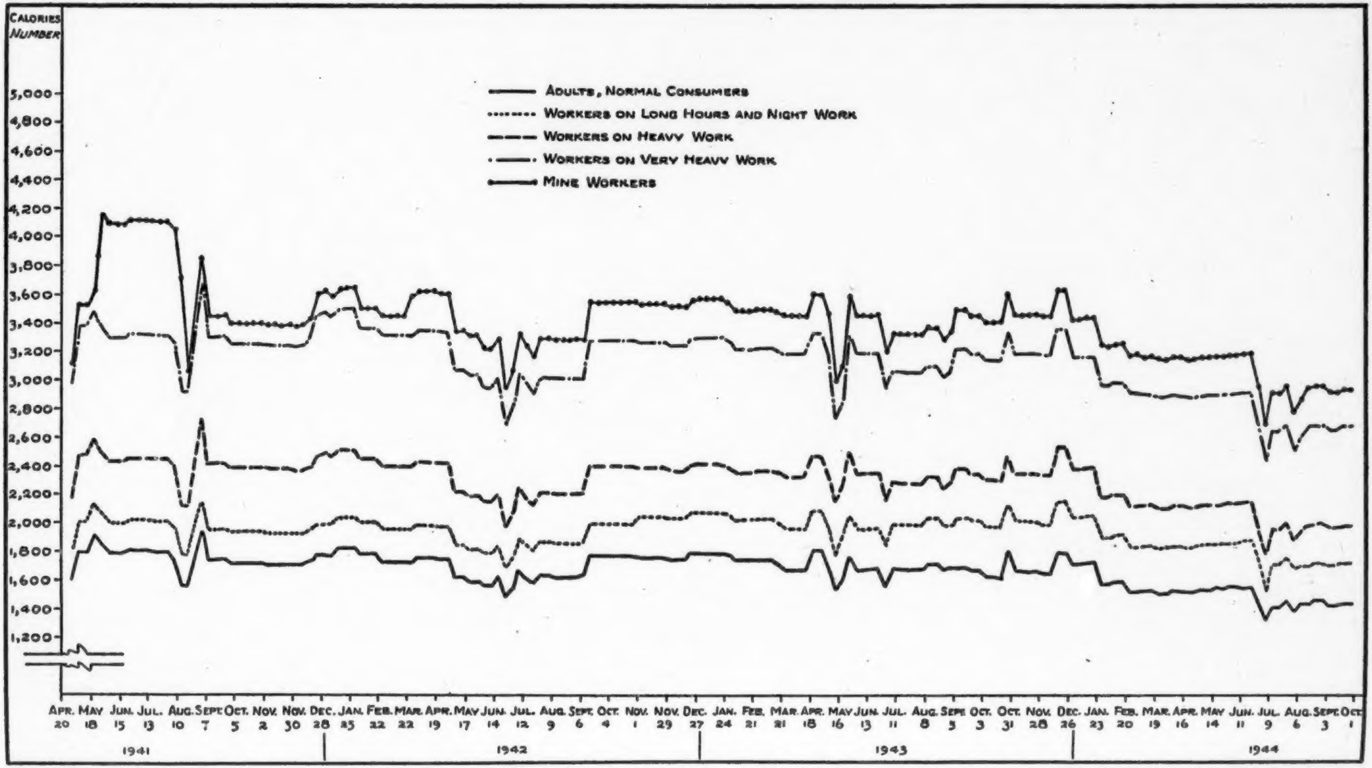

Fig. 4. Calories per day in weekly food rations distributed throughout the Netherlands to adult normal consumers and to groups which received supplementary rations from April 27, 1941 to October 1, 1944.

Fig. 4. Calories per day in weekly food rations distributed throughout the Netherlands to adult normal consumers and to groups which received supplementary rations from April 27, 1941 to October 1, 1944.

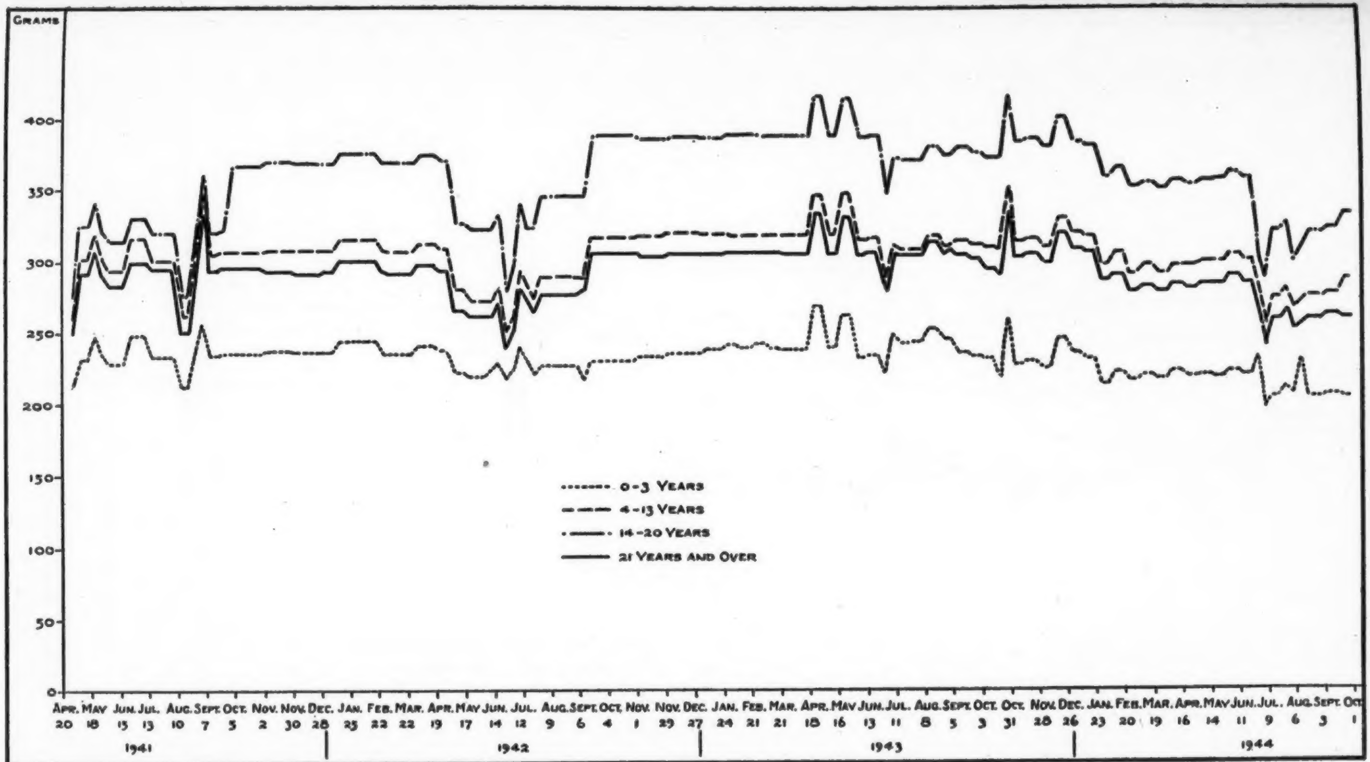

Fig. 5. Grams of carbohydrate per day in weekly food rations distributed through out the Netherlands to different age groups from April 27, 1941 to October 1, 1944.

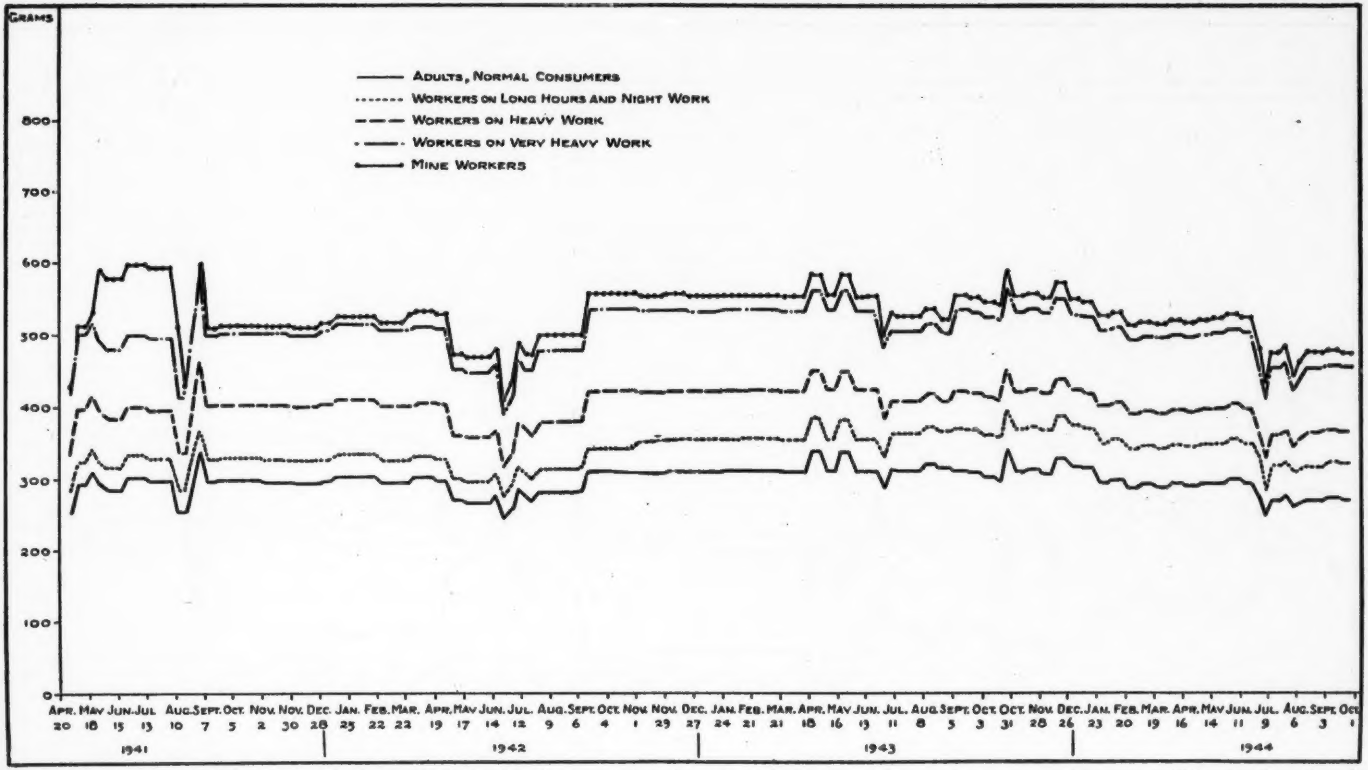

Fig. 6. Grams of carbohydrate per day in weekly food rations distributed throughout the Netherlands to adult normal consumers and to groups which received supplementary rations from April 27, 1941 to October 1, 1944.

Fig. 6. Grams of carbohydrate per day in weekly food rations distributed throughout the Netherlands to adult normal consumers and to groups which received supplementary rations from April 27, 1941 to October 1, 1944.

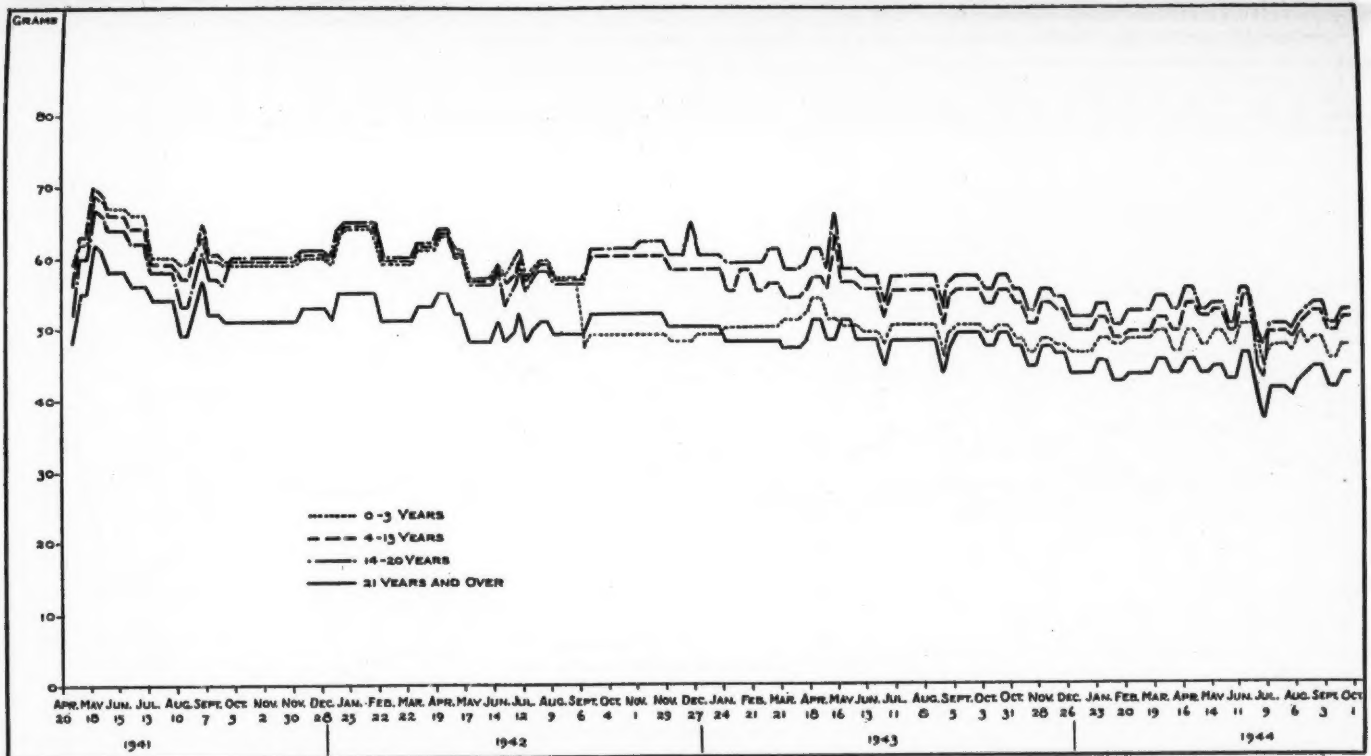

Fig. 7. Grams of protein per day in weekly food rations distributed throughout the Netherlands to different age groups from April 27, 1941 to October 1, 1944.

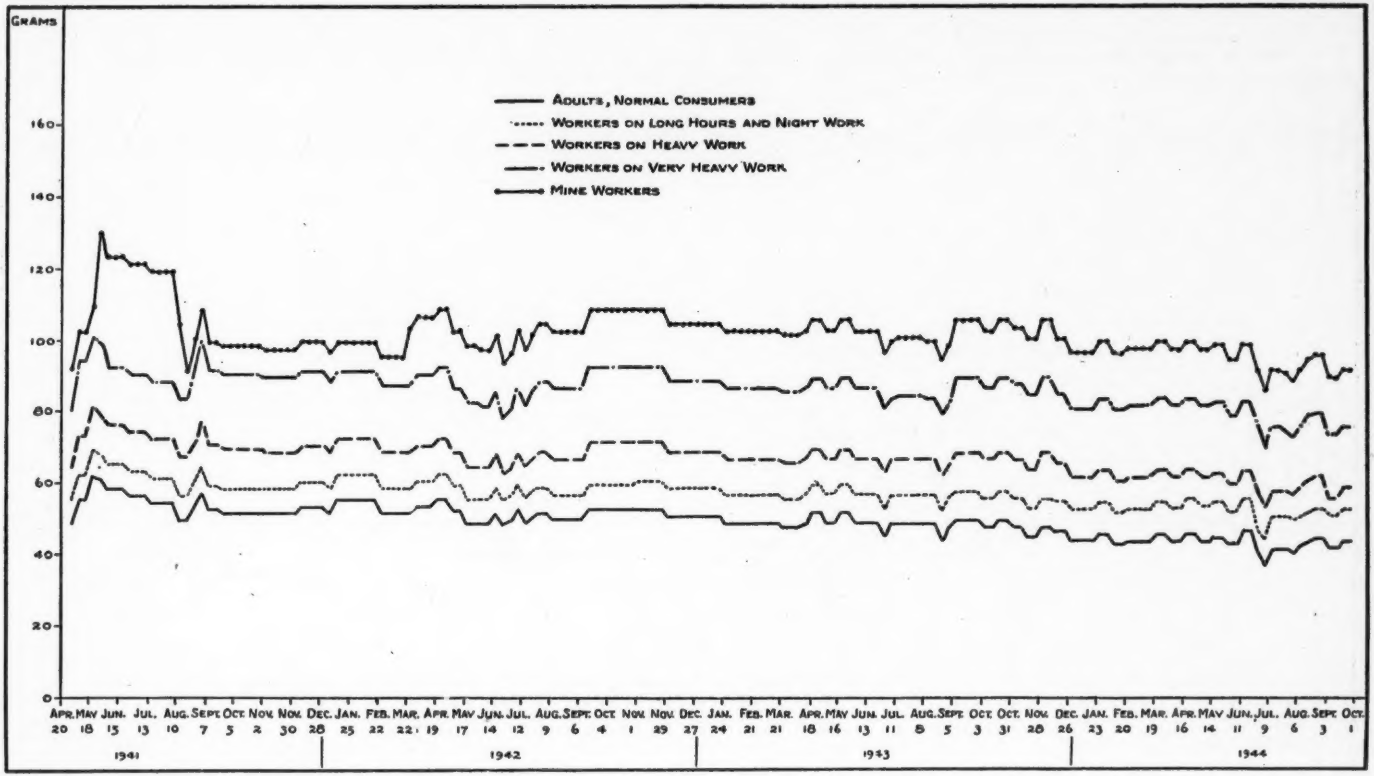

Fig. 8. Grams of protein per day in weekly food rations distributed throughout the Netherlands to adult normal consumers and to groups which received supplementary rations from April 27, 1941 to October 1, 1944.

rations from April 27, 1941 to October 1, 1944.

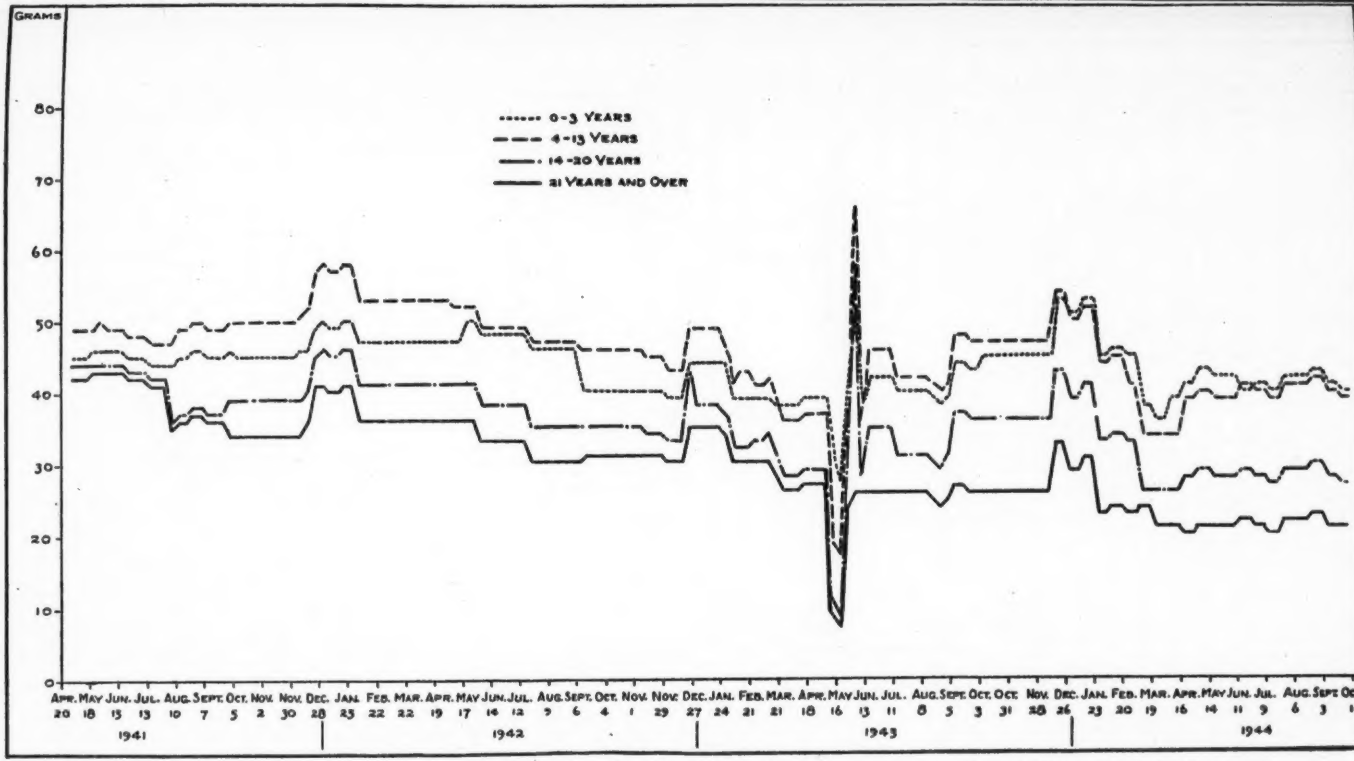

Fig. 9. Grams of fat per day in weekly food rations distributed throughout the Netherlands to different age groups from April 27, 1941 to October 1, 1944.

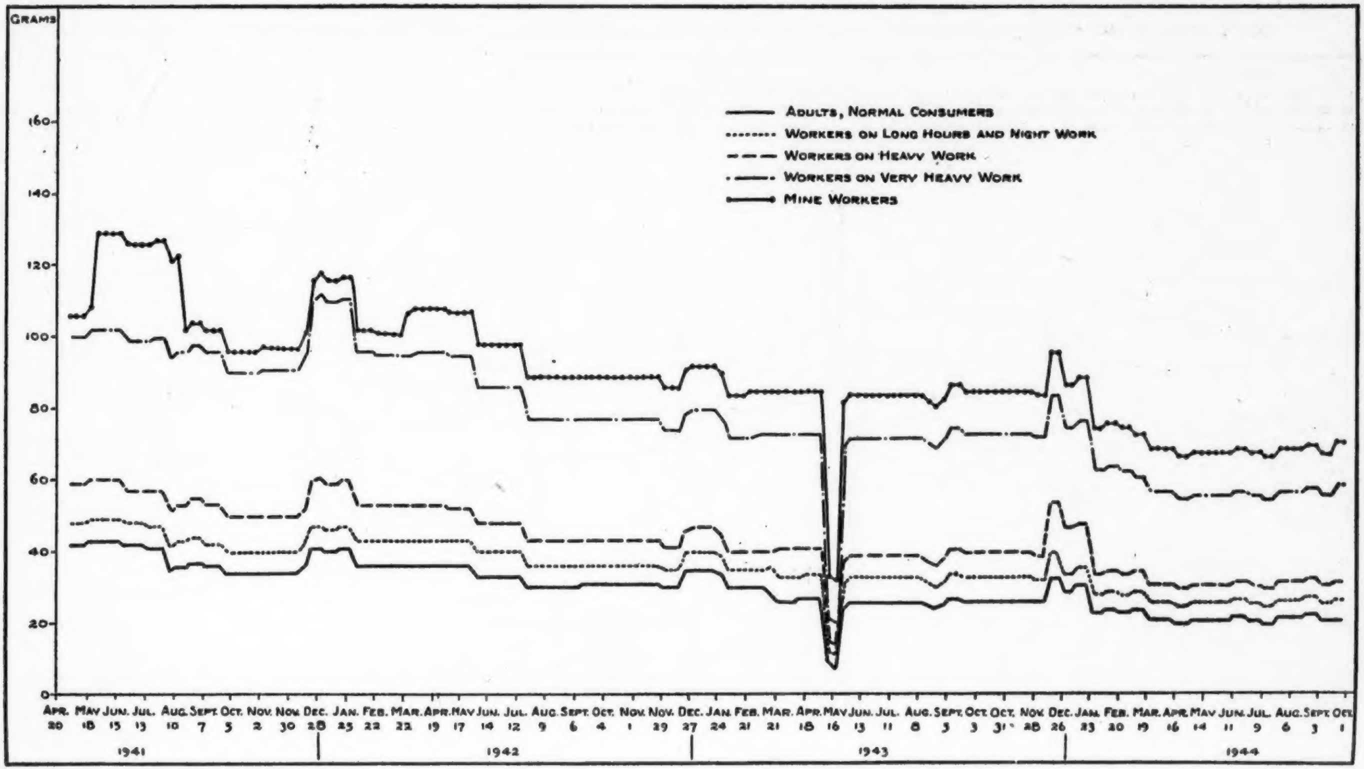

Fig. 10. Grams of fat per day in weekly food rations distributed throughout the Netherlands to adult normal consumers and to groups which received supplementary rations from April 27, 1941 to October 1, 1944.

average or normal consumers. Similarly, ration values are shown for groups of workers who received supplementary rations, *viz.*, workmen on long hours or night jobs, those on heavy work, those on very heavy work, and coal miners. These data are summarized by quarters in Appendix Tables 1 and 2 (pp. 356, 357) in which estimated average daily amounts of calcium, phosphorus, iron, vitamin A, thiamin, and vitamin C also are shown.

On October 14, 1939, rationing was started, sugar being the first rationed item. Other articles followed gradually. The number of rationed articles materially increased after June, 1940. Rationed were: tea and coffee, bread and flour, rice, butter and margarine, oatmeal, vermicelli, meat, cheese, groats, eggs, coffee-substitute, and milk, in the order mentioned; and on April 26, 1941 even potatoes were rationed, followed later on by jam, skim milk, cocoa powder, and some typical war products, such as children's beverage powder, and mixed flour. Milk rationing had a somewhat irregular course. From April 19, 1941, standardized milk was allotted to all groups; after August 2, 1941, however, only to children under 14 years old. Skim milk was not on the ration then, but could be had only in limited quantities. On September 6, 1942 this article too was rationed. During the period that no standardized milk was distributed and skim milk was still unrationed, the caloric value of milk in the diet was calculated on the basis of a weekly consumption of one and three-quarter litres of skim milk by persons aged 14 years and over.

Without exaggeration it may be said that from April 26, 1941, the day when potatoes were rationed, practically the whole diet was "on the ration." The charts showing food values of rationed foodstuffs start on that day and continue until the memorable date of September 17, 1944 and are for the whole of Holland. On that very day the Netherlands was, with respect to distribution areas, divided into three large parts: the Western provinces,

i.e., the provinces of Noord-Holland, Zuid-Holland, and Utrecht; the Southern provinces, *i.e.,* the areas south of the big rivers; and the Eastern provinces, *i.e.,* Groningen, Friesland, Drenthe, Overyssel, and part of Gelderland.

From Figures 3 and 4, showing the caloric value, it appears that up to approximately the middle of 1943 the aggregate caloric level remained much the same except for some temporary deviations. Then a reduction came which, especially after the beginning of 1944, became larger and larger. The results of the 1943 crop did not come up to expectations, among other things due to lack of fertilizers, shortage of agricultural implements, labor, and last but not least the increasing black market. The inundations in 1944 did the rest.

The composition of the rations which supplied these calories, however, underwent a radical change in the course of years, as also appears from the graphs. The amount of carbohydrates increased, whereas that of proteins and especially fats decreased more and more. This is explained by the necessity for Dutch agriculture to adapt itself to new circumstances as a result of the lack of imports. The production of cereals and potatoes had increased; that of meat, milk, and eggs had decreased. Up to July, 1943, the drop in the production of proteins and fats could be offset by increasing the production of foodstuffs with a high carbohydrate content. For reasons mentioned above, this method could no longer be applied after this date.

Thus far, the general course of the rationing of foodstuffs has been considered. If week to week variations shown in the charts are studied, some more striking facts present themselves.

In the period from April to September of every year, the graphs for calories and carbohydrates regularly show a decline, although during this decline some rather large fluctuations will be noted. These fluctuations are due to the transition from the distribution of the old potato crop to the new one. This transi-

tion invariably caused a temporary cutting down of the potato ration. Sometimes, if the supplies fell considerably short of expectations, the reduction amounted to twice the usual one. In most cases this temporary reduction was to the best of our abilities offset by putting quantities of pulses into distribution which, however, took place at more or less irregular intervals.

This periodic cut in rations, however, was caused also by another fact. During the same periods, the graphs for fats show much the same fluctuations and the temporary decrease in fat rations also affected the total amount of calories. As a matter of fact, the margarine, which was being manufactured from the home-produced rape seed, was not yet sufficient to compensate for the decrease in butter.

Another variation which occurred every year, and which is clearly apparent from the graph for fats, is the temporary rise between Christmas and New Year's, caused by the supplementary rations of butter or oil, cheese, and syrup in these periods.

The violent fluctuations in August, 1941, were caused by a temporary halving of the potato ration, which was offset immediately after by a proportional rise.

On studying the graphs, one can see that the lines for the youngest children drop after September 6, 1942, whereas those for the other groups have a rising trend. What is the cause of this phenomenon?

As of September 6, 1942, the weekly milk ration for the very youngest had to be reduced from seven litres to five and one-quarter litres; on that date skim milk was put into distribution, and this had to be taken into account in distributing the milk supply. On that very day the potato ration was increased for all groups; for the very youngest, however, the caloric value of this rise did not counterbalance the reduction caused by cutting down the milk ration.

In April, 1943, a sharp rise in calories was followed by a sharp

fall. The old potato crop had to be cleared quickly and a higher ration was given temporarily. Immediately after this the fat ration showed a trend to sink to its lowest possible level, soon rallied, however, and sometime afterwards was reestablished for the normal consumers and the labor groups at its original level. Persons under 20 years of age were given the opportunity to make up for the deficiencies by a temporary increase in rations. This is clearly shown by graphs of the fat rations and can be accounted for as follows: The situation with respect to fats was precarious and for some time young persons had not received their supplementary rations. In May, 1943, the Germans called up the former Dutch forces to be carried off as prisoners of war. The Dutch population replied to this action with strikes. Without informing the Dutch food authorities, the Germans then published an article in the newspapers to the effect that, owing to the strike, appreciable quantities of milk had been lost and this had caused an inadequate production of butter; therefore, the current butter coupon had to be continued for four weeks, no new coupon being made available. However, the authorities managed to give young persons this butter by an extra coupon. For older persons and the labor groups, such a thing was out of the question. Not until September 5, 1943, was the fat ration for children normal again; before that date it more or less fluctuated. During the transition to the new sugar crops, as of October 3, 1943, this ration had to be temporarily decreased. On October 24th of the same year, the deficiency was made up for by a double sugar ration, which is shown in the graph by a peak in the curve.

After the last supplementary rations about Christmas 1943, the general decrease of rations began in the spring of 1944. Thus in March, the fat ration was cut down, the skim milk ration already having been reduced in February. In April, 1944, the fat ration for young persons was raised again; this was impossible

for older persons and the labor groups. At the end of June, the periodic difficulties with the potato supply, caused by the transition to the new crops, occurred. In spite of enormous transport difficulties the rations were kept up to three kilograms. There were but limited possibilities for compensations at the time of the lowest ration, *i.e.*, during the latter half of June. People were provided twice with an extra supply of bread, cheese, and pulses, and had to overcome many difficulties up to September 17, 1944. The course of the rationing after that date will be discussed later on.

In general, it may be said that except for temporary deviations caused by circumstances mentioned above, rationing in the Netherlands followed a rather regular course. The graphs clearly show the relative food values of the rations allotted to the different groups of consumers. One should bear in mind, however, especially in judging the graphs for labor groups, that the value of the coupon-free meals, which have been discussed, has not been included. The distribution of vegetables, fruit, and fish likewise has not been taken into account. Local differences in the supply of these foods were appreciable; furthermore, they furnished negligible amounts to the food values under discussion.

EMBARGO

The greatest difficulties in the food supply originated from the beginning of the offensive by Montgomery near Arnhem and Nijmegen. The Dutch Government in London declared a general railroad strike on September 17, 1944. It is well known how this order was carried into effect. On September 22nd, Dr. H. M. Hirschfeld and Mr. S. L. Louwes, Secretary General of the Ministry of Agriculture and Fisheries and Director General for the Food Supply, respectively, were informed in the name of Reichskommissar Seyss-Inquart that they had to address a summons to the Dutch people to the effect that, if the railroad

strike were not lifted immediately, the long-dreaded famine was bound to come. It was most obvious that this summons was meant to cancel the railroad strike. Messrs. Hirschfeld and Louwes were positive in their refusal although they knew that, as a retaliatory measure, an embargo would no doubt be proclaimed by the "Reichskommissar." The proclamation of this embargo, which indeed took place, prohibited the transport of all food from the northern and eastern production areas to the densely populated consumption centers in the western part of the country. It is now clear to everybody what this meant to Holland. The consequences had been foreseen by the Dutch authorities. They addressed frequent, but ineffectual warnings about this matter to the "Reichskommissar," pointing out to him the lack of sufficient stocks in the western provinces and the dangers the approaching winter would be sure to result in, if he did not see to it that stocks were formed in time.

Not until November 8th was the prohibition to convey food to the western provinces partly lifted. It was, however, a considerable time before the formation of the Central Ship Owners Food Supply ("Centrale Reederij Voedselvoorziening") caused the situation to improve slightly. At the very time when this organization was capable of carrying out its activities, frost set in; this brought to a complete stop the supplying of food and the forming of stocks in the western provinces. It was too late! Figure 11 shows the weekly supply of food shipped from the eastern to the western provinces in the period October 30, 1944 to June 30, 1945.

In the meantime, the inhabitants of the western provinces had consumed all the stock on hand and real famine had set in. People were forced more and more to leave the towns in search of food in the production areas. Many of them, however, did not live through these food expeditions.

Immediately after the unsuccessful attack near Arnhem, the

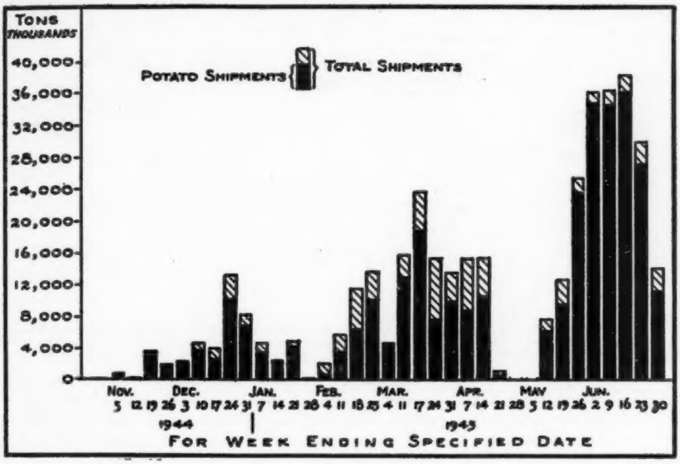

Fig. 11. Weekly shipments of all foodstuffs and of potatoes from Eastern Netherlands to Western Netherlands from October 30, 1944 to June 30, 1945.

Director General for the Food Supply urged our Government in London to relief action. After the proclamation of the embargo this action was asked for repeatedly, and it was even suggested that food be dropped from the air. In January, 1945, relief came: the starving population received consignments from the Swedish Red Cross, followed by those from the International and Swiss Red Cross which of course somewhat alleviated this most serious situation. When the last relief consignments were all but exhausted, the Allies, on April 29, 1945, began to drop food from airplanes. This method of rendering assistance was possible because the tide of war had turned. Supplies by land and sea soon followed. Nevertheless, during the period April 29th to May 8th, some 4,500 aircraft dropped 8,000,000 kilograms of high-quality food, representing an average per capita for the population of Western Holland of 2 kilograms.

This is not the place to give a full historical account of what preceded these "air droppings" and of the part played by the

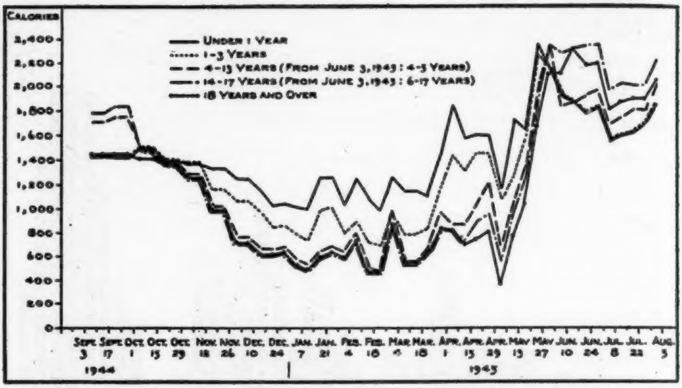

Fig. 12. Average calories per day by weekly periods for food rations, including Red Cross and S.H.A.E.F. supplies, distributed daily in Western Netherlands to different age groups from September 3, 1944 to August 5, 1945.

Ministry of Agriculture and Fisheries and, under its supervision, the Government Office for the Food Supply in Wartime. A single fact, however, ought to be mentioned in this connection.

The Allied attack across the Rhine caused the Eastern part of the country to be entirely cut off from the Western part. Then, on April 2, 1945, the Reichskommissar ordered Dr. Hirschfeld to come and see him, and informed him of the commands of the "Ober Kommando der Wehrmacht" for proceeding to an inundation of the whole Western part of the Netherlands and to devastations on an enormous scale in case of an Allied attack.

The Reichskommissar was willing to discuss with Dr. Hirschfeld how this calamity could be averted. During the negotiations he was prepared to allow food transports to the Western part of the Netherlands. After that Dr. Hirschfeld drafted a telegram with conclusions about these discussions, which was forwarded to the Chairman of the Confidents of the Netherlands Government and passed on to the Netherlands Government in London.

On April 4th, after having consulted Mr. Louwes, Dr. Hirsch-

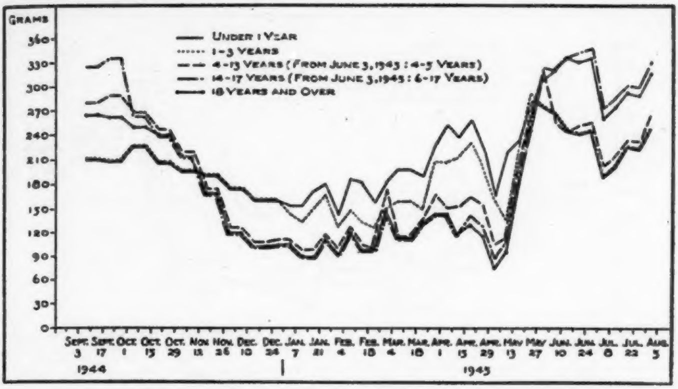

Fig. 13. Average grams of carbohydrate per day by weekly periods for food rations, including Red Cross and S.H.A.E.F. supplies, distributed daily in Western Netherlands to different age groups from September 3, 1944 to August 5, 1945.

feld got the news that the telegram had been actually sent off. As a result of the discussions between the Reichskommissar and Dr. Hirschfeld on April 2nd it became possible to arrange contact between the German authorities, the Confidents of the Netherlands Government and the Commander of the Underground Forces, so that, with the assistance of the German authorities, two representatives of the Confidents could start for that part of the country which had already been liberated in order to carry on negotiations. The discussions these Confidents carried on there prevented the attack on the Western part of the Netherlands, including the inevitable inundation by the Germans of a large part of this area. The consequences of this devastation would have been incalculable. Furthermore, these discussions led to a conference between the Allied army authorities and the Reichskommissar with his staff, which preliminaries took place on April 30, 1945 at Achterveld, and were attended by the Director General for the Food Supply and some members of his staff, as experts. At that place they came to an agreement in principle for the continuation of food supplies by air, and

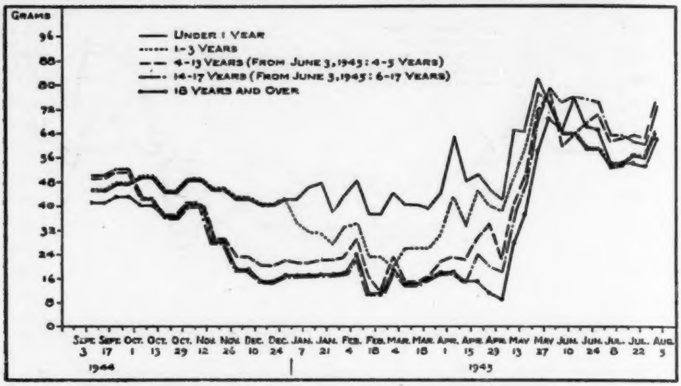

Fig. 14. Average grams of protein per day by weekly periods for food rations, including Red Cross and S.H.A.E.F. supplies, distributed daily in Western Netherlands to different age groups from September 3, 1944 to August 5, 1945.

also for sending supplies by sea and by land. This agreement was further elaborated in a conference at Wageningen on May 2, 1945. Capitulation came shortly afterwards and the liberation eagerly looked for had become a fact.

Figures 12 to 15 inclusive show the course of rationing in the Western provinces from September 3, 1944 to August 5, 1945. These charts and Appendix Table 3 (p. 358) give data for each age group on the total calories and the grams of carbohydrates, proteins, and fats per day in the ration distributed. By introducing the so-called emergency ration books and extra sheets belonging to them, distribution according to age groups was maintained. Laborers were no longer provided with supplementary rations. After a constant, gradual reduction, there was a slight rise early in January because of a rape-oil coupon being made available. Later peaks in the curves are due largely to the Red Cross consignments; the general drop is the result of the fact that local resources were running out. When on April 29, 1945, the last kilogram of potatoes and the last 400 grams of bread had been distributed, the Allies came to the rescue of the famine-stricken

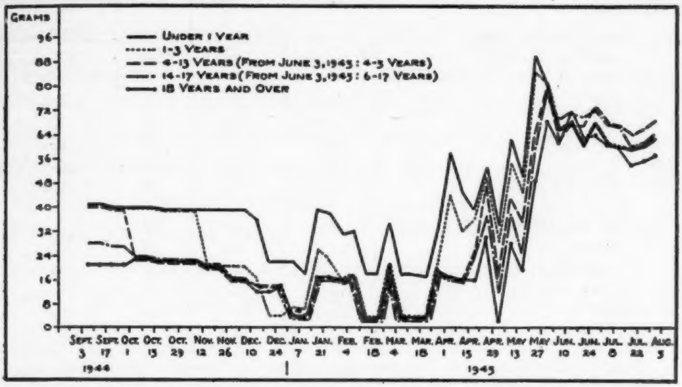

Fig. 15. Average grams of fat per day by weekly periods for food rations, including Red Cross and S.H.A.E.F. supplies, distributed daily in Western Netherlands to different age groups from September 3, 1944 to August 5, 1945.

people. Within three weeks the calories had been raised to 2,400 a day. In this connection, it is worth mentioning that the food authorities in the Western part of the country were aided by the Organization for Relief at Short Notice (Commissariaat Noodvoorziening) founded in the Southern part, which furnished a large supply of food in the shortest possible space of time and thus brought about the above-mentioned quick increase of rations (4).

Improvements in Rationing

The Southern, Northern, and Eastern provinces never suffered as bad a shortage of foodstuffs as the Western. Before the liberation of the Western part of Holland, these provinces were on a much higher caloric level than the areas that were still occupied. For a short period after the liberation, it was just the other way around. In the Western provinces care was taken that the rations after the starvation period had the highest possible content in proteins and fats. Afterwards it was the duty of the authorities in charge to get uniform rationing all over the country.

Age Groups and Special Groups	Calories	Proteins Gms.	Fats Gms.	Carbohydrates Gms.
Under 1 Year	1,800	51	62	250
2- 4 Years	1,900	54	62	265
5-14	2,475	70	65	390
15-20	2,650	75	65	425
Adults—Normal Consumers	2,300	61	58	370
Workers on Long Hours and Night Jobs	2,675	71	67	430
Heavy Workers	3,150	84	77	511
Heaviest Workers	4,000	106	105	633
Expectant and Nursing Mothers	3,200	94	96	465
Coal Miners	5,400	157	144	826

Table 7. Calories, protein, fat, and carbohydrate in the rations of different age groups and other special groups in the Netherlands after January 1, 1946.

Except for some slight deviations this end was attained in August, 1945.

The average rations for a normal consumer contained approximately 2,300 calories per day. Special attention was paid to the requirements of the most important groups, *i.e.,* children, expectant and nursing mothers, sick persons, and laborers in need of supplementary rations. The number of calories and grams of proteins, fats, and carbohydrates per day furnished by the rations for these groups on January 1, 1946 are shown in Table 7.

Meanwhile, some products such as groats, rolled oats, pulses, rusks, and biscuits had gone off the ration. This rendered the continuation of the graphs impossible, as it would be necessary to estimate some of the values.

Unfortunately, since January 1st, it has been necessary to cut the ration twice due to the world food shortage. As of July 1st, the ration to normal consumers supplied about 1,850 calories, including estimated amounts for foods not rationed.

Death and Disease Symptoms

Even during the time our country was occupied by the Nazis,

the Pouls Committee, already referred to, regularly reported on the public health. These strictly confidential communications were used by the Director General for the Food Supply in determining the course to be followed. In the beginning the results were not unfavorable. However, the state of health of the school children, in fact, public health in general, appeared to become gradually worse and worse.

This is clearly illustrated by the appreciable increase in the number of accidents in factories and workshops, which rose from 22.9 per thousand during the first five months of 1939 to 138.5 per thousand during the corresponding period in 1943. Although it is by no means impossible that psychological and technical factors exercised their influence on these figures, Penris (5) is of the opinion that nutrition probably is responsible for this increase.

From the mortality rates for tuberculosis, it appears that the resistance of the population greatly decreased during the occupation. The rate more than doubled from 1939 to 1944, as appears from the following figures:

Annual Death Rate from Tuberculosis Per 10,000 Population

1939	*1940*	*1941*	*1942*	*1943*	*1944* (first half-year)
4.10	4.37	5.92	6.13	6.99	8.28

Later data are not available because of war conditions.

More detailed information is available for school children than for adults. These data were provided by the provisional reports of the Pouls Committee, which will be published in full in due course. From these, it appears that from 1941 the average weight of the children in all age groups showed a tendency to decrease. The numbers of children showing a positive Pirquet reaction increased appreciably, and decay of the teeth increased even more.

These conditions were found first in children in orphanages,

and later on also in children of the larger towns, but in a far less degree in children in small towns. No data are available for farmers' children.

Another condition, formerly seen only very seldom but recently of rather frequent occurrence, was volvulus of the sigmoid and prolapsus of anus and rectum. This has been commented upon by Schepel (6). This condition which is often seen in Russia and the Baltic countries is attributed to inadequate nutrition.

The above refers to the period preceding the famine. It was not long before people experienced the consequences of famine, as is apparent from the large increase in the rate of mortality. Early in January, 1945, the first obvious cases of death as the result of starvation were reported to the Government Office. The numbers of deaths in twelve municipalities in the first half of 1945 are shown in Tables 8, 9, and 10, and are compared with the deaths in the corresponding period of 1944. These data are from tabulations made by the Central Bureau of Statistics. The total deaths

Table 8. Numbers of deaths in twelve municipalities in the first half of 1944 and 1945.

Municipality	Number of Deaths in First Six Months		Ratio 1944=100	Absolute Difference
	1944	1945		
Amsterdam	4,401	9,737	221	5,336
Rotterdam	3,255	7,854	241	4,599
The Hague	2,389	5,811	243	3,422
Rijswijk	91	211	232	120
Voorburg	188	449	239	261
Delft	424	863	204	439
Leiden	625	1,130	180	505
Gouda	287	519	181	232
Schiedam	396	737	186	341
Vlaardingen	180	369	205	189
Dordrecht	424	603	142	179
Hilversum	495	839	169	344
Total	13,155	29,122	221	15,967

Age Group	Number of Deaths		Excess Over Number in First 6 Months, 1944		Ratio 1944=100	
	Male	Female	Male	Female	Male	Female
All Ages	17,915	11,207	11,252	4,715	269	173
Under 1 Year	1,437	1,002	901	663	268	296
1-4 Years	501	379	253	193	202	204
5-64 Years	7,099	3,318	4,289	896	253	137
65 Yrs. and Over	8,878	6,508	5,809	2,963	289	184

Table 9. Deaths according to sex and age groups in twelve municipalities in the first half of 1945 and excess over 1944.

more than doubled; for males the increase was 169 per cent and for females it was 73 per cent. Recently W. R. Aykroyd, Director of the Nutrition Research Laboratory at Conoor in India, stated that this phenomenon was observed also during the sweeping famine in that country. A satisfactory explanation has not as yet been found.

Table 10. Weekly deaths in twelve municipalities in the first half of 1945.

Week of Year	The Hague War Victims Excl.	Twelve Municipalities		Week of Year	The Hague	Twelve Municipalities	
		Total Deaths	Excess Over 1944			Total Deaths	Excess Over 1944
1st	128	763	202	14th	287	1,300	710
2nd	171	912	393	15th	270	1,303	782
3rd	236	1,064	548	16th	244	1,101	643
4th	241	1,246	711	17th	231	1,168	707
5th	274	1,579	1,103	18th	220	1,262	790
6th	310	1,417	906	19th	252	1,325	889
7th	298	1,362	848	20th	196	948	508
8th	326	1,320	778	21st	133	828	369
9th	306	1,330	683	22nd	106	726	246
10th	271	1,452	824	23rd	130	693	285
11th	303	1,508	866	24th	105	599	208
12th	318	1,522	959	25th	90	581	191
13th	278	1,292	697	26th	87	521	121

The most striking symptom of starving persons is their total apathy, in spite of the fact that they often had lost their self control and were most irritable. This is one of the symptoms observed by Aykroyd. Also, insomnia during the night and sleep in the daytime occurred frequently. Peripheral nervous disorders and polyneuritis, severe cases of muscular weakness, dizziness, bad cases of anemia, edema, and polyuria, were common occurrences. Also avitaminoses and severe wound infections were reported by several doctors.

This war and the famine period have taught us, however, that the human organism is capable of far greater adaptation than was thought possible. This adaptation took place in the metabolism of the individual, which was economized. However, in contrast with the investigations on experimental starvation in man by Keys and collaborators (7), the adaptation of the human body took place very slowly.

For further details about the symptoms observed in starving persons, the report by J. B. Stolte (8) may be referred to.

Conclusion

In this article attempt has been made to summarize the course of the Dutch food supply during World War II; some miscellaneous historical facts have been recorded, as well as occasionally the motives or circumstances that account for the policy pursued.

A comparison with rationing during World War I has been avoided on purpose, since from 1914 until 1918 the war situation was quite different. First of all, the Netherlands was unoccupied and the Dutch Government was free to determine its own policy. In addition, it should be borne in mind that since 1918 the population has increased by 40 per cent, whereas the acreage of arable land has increased by at most 6 per cent.

At present, attempts are being made to bring food up to the

prewar level as quickly as possible. To attain this end, however, many international obstacles have to be removed; among other things there are the monetary problem and the allocation of food and raw materials from the world stock. The world food shortage, however, is very serious; therefore, it cannot be expected that in 1946 the prewar consumption level will be reached.

References

1. Jansen, B. C. P.: Het belang van de nieuwe ontwikkeling van de voedingsleer voor de Nederlandsche landbouw. *Landbouwkundig Tijdschrift,* 1940, 52, 103.

2. Banning, C.: De Voeding te Zaandam in 1929-1930. *Proefschrift,* Utrecht, 1931.

   Statistische Mededeelingen van het Bureau van Statistiek der Gemeente Amsterdam M. 116: Inkomsten, Uitgaven, Verbuik en Physiologische Waarde van de voeding van 184 gezinnen uit verschillende kringen der Bevolking gedurende de periode 1 Maart, 1934 — 28 Februari, 1935. Amsterdam, 1941.

   Huishoudrek-eningen van 598 gezinnen uit verschillende deelen van Nederland over de perioden 29 Juni, 1935 t/m 26 Juni, 1936 en 28 September, 1935 t/m 25 September, 1936. Uitgave Centraal Bureau van de Statistiek, Gravenhage (2dln 1937 en 1938).

   Voeding Gezondheid en Financieele Toestand van 700 werkloozen gezinnen verspried over geheel Nederland. 's Gravenhage, Algemeene Landsdrukkerij, 1940 (2 dln).

3. Meulen, J. B. van der: Notitie over de Bemestingswaarde van den Nederlandschen krachtvoeder import. *Landbouwkundig Tijdschrift* 1946, 58, 33.

4. Baarle, W. H. Van: Slag cm B, Een herinnering in woord en beeld aan het Commissariaat Noodvoorziening 1945 (niet in den handel).

5. Penris, P. W. L.: Het stijgende aantal Ongevallen. *Tijdschrift Sociale Geneeskunde,* 142, 20, 125.

6. Schepel, J. A. C.: Het volvulus van het sigmoid en distributie. *Nederlandsch Tijdschrift voor Geneeskunde,* 1943, 87, 1016.

7. Keys, Brozek, Henschel, Mickelsen and Taylor: Experimental Starvation in Man. University of Minnesota, October 15, 1945, 48 pp.

   Keys, Taylor, Mickelsen, Henschel and Brozek: Rehabilitation Following Experimental Starvation in Man. University of Minnesota, January 15, 1946, 124 pp.

8. Stolte, J. B.: De gevolgen van ernstige Ondervoeding. *Voeding,* 1945, 6, 113.

Appendix Table 1. Number of calories and amounts of carbohydrates, proteins, fats, minerals, and vitamins per day in foods distributed in The Netherlands to children and youths, by age group, April 27, 1941 to September 30, 1944.

Year and Quarter	Calories No.	Carbo-hydrates Gms.	Pro-tein Gms.	Fats Gms.	Cal-cium Gms.	Phos-phorus Gms.	Iron Mgs.	Vitamin A Int. Units	Thiamin Mgs.	Ascorbic Acid Mgs.
	Ages 0-3 Years									
1941										
II	1,661	235	67	45	1.45	1.60	10	3,070	1.14	32
III	1,711	253	65	45	1.47	1.61	10	2,618	1.15	79
IV	1,732	251	66	47	1.50	1.51	10	4,346	1.11	67
1942										
I	1,706	243	65	48	1.46	1.49	9	1,656	1.06	37
II	1,656	231	64	48	1.48	1.56	9	3,233	1.04	42
III	1,677	246	62	46	1.40	1.53	9	2,658	1.02	81
IV	1,650	253	55	41	1.21	1.37	9	5,324	.96	77
1943										
I	1,623	250	53	41	1.15	1.33	9	2,309	.91	48
II	1,596	250	55	38	1.15	1.37	10	3,174	.95	53
III	1,667	261	54	41	1.16	1.42	10	2,569	1.01	101
IV	1,664	249	53	47	1.15	1.35	9	4,202	.94	69
1944										
I	1,572	231	50	45	1.11	1.31	8	2,119	.93	46
II	1,519	227	52	41	1.10	1.32	9	3,085	.92	49
III	1,531	228	51	42	1.14	1.35	9	2,752	.94	81
	Ages 4-13 Years									
1941										
II	1,963	300	67	49	0.91	1.51	15	2,898	1.17	39
III	2,021	321	64	48	0.92	1.52	15	2,445	1.22	112
IV	2,072	322	66	52	0.96	1.53	15	4,193	1.24	95
1942										
I	2,055	314	65	55	0.92	1.50	15	1,526	1.20	53
II	1,928	290	63	51	0.93	1.47	14	3,082	1.15	57
III	1,959	309	64	47	0.92	1.51	15	2,513	1.21	115
IV	2,101	338	65	46	0.97	1.57	16	5,306	1.31	113
1943										
I	2,019	330	60	45	0.81	1.44	15	2,234	1.21	68
II	1,948	330	60	37	0.85	1.46	16	3,064	1.24	79
III	2,016	330	60	45	0.91	1.53	15	2,549	1.29	140
IV	2,056	333	58	49	0.91	1.49	14	4,158	1.26	103
1944										
I	1,897	311	52	43	0.81	1.41	14	2,050	1.23	65
II	1,835	302	55	39	0.84	1.44	15	3,023	1.22	73
III	1,798	295	54	40	0.89	1.44	14	2,687	1.20	112
	Ages 14-20 Years									
1941										
II	1,982	320	64	44	0.62	1.40	16	2,723	1.14	36
III	1,988	336	61	40	0.63	1.39	16	2,169	1.17	109
IV	2,217	383	67	40	0.70	1.55	18	3,855	1.39	125
1942										
I	2,200	375	66	43	0.65	1.52	17	1,187	1.34	70
II	2,040	342	63	41	0.66	1.46	17	2,744	1.26	75
III	2,093	364	64	36	0.66	1.51	18	2,176	1.33	150
IV	2,293	408	68	36	0.71	1.62	19	4,969	1.49	147
1943										
I	2,230	400	63	35	0.60	1.52	18	1,955	1.41	88
II	2,160	400	63	29	0.62	1.53	18	2,797	1.43	105
III	2,169	392	61	33	0.65	1.54	18	2,212	1.43	179
IV	2,253	401	60	39	0.66	1.53	18	3,820	1.44	138
1944										
I	2,066	371	54	33	0.58	1.48	18	1,751	1.42	86
II	1,970	358	56	28	0.60	1.49	18	2,699	1.39	96
III	1,879	339	54	29	0.62	1.43	17	2,351	1.31	145

Appendix Table 2. Number of calories and amounts of carbohydrates, proteins, fats, minerals, and vitamins per day in foods distributed in The Netherlands to adults, according to type of work, April 27, 1941 to September 30, 1944.

Year and Quarter	Calories No.	Carbo-hydrates Gms.	Pro-tein Gms.	Fats Gms.	Cal-cium Gms.	Phos-phorus Gms.	Iron Mgs.	Vitamin A -Carotene Int. Units	Thiamin Mgs.	Ascorbic Acid Mgs.
	Adults — General									
1941										
II	1,828	289	59	42	0.61	1.28	15	2,723	1.05	36
III	1,852	310	57	38	0.62	1.30	15	2,169	1.09	109
IV	1,828	308	58	36	0.66	1.30	14	3,802	1.11	92
1942										
I	1,810	299	57	38	0.61	1.27	14	1,135	1.07	50
II	1,699	277	55	35	0.63	1.25	14	2,691	1.03	55
III	1,750	299	56	32	0.62	1.28	14	2,124	1.08	113
IV	1,876	326	57	32	0.67	1.35	15	4,917	1.18	110
1943										
I	1,822	316	52	32	0.55	1.25	14	1,903	1.10	65
II	1,724	317	53	23	0.56	1.25	15	2,744	1.12	76
III	1,783	323	52	26	0.61	1.30	15	2,133	1.17	137
IV	1,784	321	51	28	0.61	1.26	15	3,690	1.14	101
1944										
I	1,656	299	45	26	0.54	1.21	14	1,633	1.12	63
II	1,585	288	48	21	0.56	1.22	14	2,601	1.10	70
III	1,529	279	45	22	0.59	1.21	14	2,261	1.07	109
	Workers on Long Hours and Night Work									
1941										
II	2,032	320	66	48	0.62	1.43	17	2,757	1.16	37
III	2,056	341	64	44	0.64	1.45	17	2,203	1.20	109
IV	2,032	339	65	42	0.68	1.45	17	3,836	1.22	93
1942										
I	2,027	330	64	44	0.63	1.42	16	1,188	1.18	51
II	1,917	308	62	42	0.65	1.40	16	2,746	1.14	55
III	1,969	329	63	39	0.64	1.43	17	2,179	1.19	113
IV	2,146	367	66	39	0.69	1.52	18	4,973	1.33	116
1943										
I	2,113	366	61	38	0.58	1.45	17	1,958	1.27	71
II	1,999	363	61	29	0.58	1.44	17	2,792	1.29	84
III	2,099	376	60	33	0.64	1.51	18	2,189	1.37	158
IV	2,132	379	60	35	0.65	1.50	18	3,745	1.36	120
1944										
I	1,970	353	55	30	0.57	1.44	17	1,689	1.34	75
II	1,897	343	57	26	0.59	1.46	18	2,656	1.32	84
III	1,789	328	54	28	0.61	1.40	16	2,317	1.23	121
	Workers on Heavy Work									
1941										
II	2,455	388	76	59	0.66	1.68	20	2,902	1.38	48
III	2,499	411	75	56	0.68	1.70	20	2,348	1.46	147
IV	2,485	414	76	52	0.72	1.72	20	3,970	1.50	125
1942										
I	2,485	407	74	55	0.67	1.68	20	1,328	1.46	71
II	2,304	373	71	52	0.69	1.62	19	2,862	1.38	75
III	2,339	397	73	45	0.68	1.67	20	2,259	1.44	151
IV	2,534	440	76	44	0.73	1.78	21	5,048	1.60	148
1943										
I	2,468	431	69	44	0.62	1.68	20	2,033	1.52	89
II	2,379	426	71	36	0.62	1.68	21	2,855	1.54	105
III	2,398	424	71	40	0.67	1.70	20	2,264	1.55	179
IV	2,463	433	71	43	0.68	1.70	20	3,820	1.57	139
1944										
I	2,274	403	63	37	0.61	1.65	20	1,756	1.54	86
II	2,172	391	65	31	0.62	1.66	21	2,712	1.52	98
III	2,064	371	61	32	0.64	1.60	19	2,372	1.42	145
	Workers on Very Heavy Work									
1941										
II	3,332	487	93	101	0.73	2.11	27	3,437	1.74	59
III	3,375	509	93	98	0.75	2.15	27	2,875	1.86	185
IV	3,367	515	97	93	0.78	2.18	27	4,475	1.92	159
1942										
I	3,425	513	93	101	0.74	2.13	26	1,906	1.87	92
II	3,156	469	90	92	0.75	2.04	25	3,377	1.74	96
III	3,156	494	92	81	0.74	2.10	26	2,668	1.83	189
IV	3,413	554	97	79	0.80	2.26	28	5,439	2.05	186
1943										
I	3,332	543	90	78	0.69	2.13	27	2,424	1.95	112
II	3,187	542	91	64	0.69	2.13	27	3,185	1.97	134
III	3,183	524	89	73	0.73	2.12	26	2,655	1.93	222
IV	3,304	545	91	75	0.74	2.16	27	4,211	2.00	176
1944										
I	3,048	508	83	65	0.70	2.12	27	2,150	1.97	110
II	2,931	497	84	57	0.71	2.12	27	3,058	1.94	126
III	2,741	460	79	58	0.70	2.00	25	2,708	1.78	181

Appendix Table 3. Number of calories and amounts of carbohydrates, proteins, and fats in foods distributed in three areas[1] of The Netherlands to various age groups and to different types of workers, October, 1944 to December, 1945.

Year and Quarter	Calories No.			Carbohydrates Gms.			Protein Gms.			Fat Gms.		
	West	North-east	South	West	North-east	South	West	North-east	South	West	North-east	South
	INFANTS [2]											
1944 IV	1,298	1,404	1,321	188	226	195	44	45	46	36	38	36
1945 I	1,154	1,287	1,529	178	183	226	42	44	50	26	38	44
II	1,776	1,649	1,744	241	235	256	60	58	56	59	49	51
III	1,664	1,708	1,825	219	236	249	57	57	60	59	56	60
IV	1,672	1,672	1,663	234	234	233	54	53	53	54	54	53
	PRESCHOOL [3]											
1944 IV	1,205	1,404	1,321	188	226	195	44	45	46	26	38	36
1945 I	865	1,287	1,529	150	183	226	28	44	50	12	38	44
II	1,644	1,649	1,747	225	235	256	54	58	54	55	49	52
III	1,696	1,730	1,819	225	240	254	58	58	58	59	56	59
IV	1,744	1,744	1,735	248	248	245	56	56	56	54	54	53
	SCHOOL AGES [4]											
1944 IV	1,073	1,401	1,256	184	249	221	31	39	41	19	23	19
1945 I	664	1,284	1,778	119	224	308	19	37	58	10	22	31
II	1,460	1,729	2,016	204	276	331	48	60	59	47	39	46
III	2,068	2,109	2,221	299	318	348	69	69	67	62	57	57
IV	2,321	2,321	2,312	372	372	371	70	70	69	55	55	55
	ADOLESCENTS [5]											
1944 IV	1,044	1,390	1,261	178	246	224	29	39	41	19	23	19
1945 I	619	1,276	1,905	112	223	349	16	36	57	10	22	26
II	1,509	1,641	2,124	219	268	378	48	56	59	45	34	36
III	2,345	2,275	2,303	345	361	385	71	73	65	59	54	50
IV	2,523	2,523	2,418	415	415	406	76	76	70	55	55	51
	ADULTS — GENERAL											
1944 IV	1,035	1,380	1,241	176	244	220	29	39	41	19	23	19
1945 I	619	1,276	1,642	112	223	294	16	36	50	10	22	25
II	1,376	1,623	1,793	211	264	312	41	56	51	39	34	33
III	2,092	2,020	2,005	313	320	328	61	63	57	54	49	47
IV	2,179	2,178	2,156	359	359	356	62	62	61	50	49	48
	WORKERS ON LONG HOURS OR NIGHT WORK											
1944 IV	1,035	1,380	1,241	176	244	220	29	39	41	19	23	19
1945 I	619	1,276	1,755	112	223	313	16	36	53	10	22	28
II	1,449	1,707	2,160	226	280	371	43	58	61	39	36	42
III	2,373	2,411	2,374	376	389	387	70	75	67	60	56	56
IV	2,553	2,594	2,539	420	428	418	72	73	72	58	58	55
	WORKERS IN HEAVY OCCUPATIONS											
1944 IV	1,035	1,380	1,241	176	244	220	29	39	41	19	23	19
1945 I	619	1,276	1,840	112	223	327	16	36	55	10	22	30
II	1,512	1,771	2,435	239	290	418	44	60	68	39	37	48
III	2,727	2,702	2,668	436	436	435	80	83	74	67	63	63
IV	2,980	2,984	2,927	490	489	482	84	84	82	68	68	67
	WORKERS IN VERY HEAVY OCCUPATIONS											
1945 IV	1,035	1,380	1,241	176	244	220	29	39	41	19	23	19
1945 I	619	1,276	2,039	112	223	360	16	36	60	10	22	34
II	1,649	1,919	3,077	267	317	525	48	64	85	39	39	63
III	3,336	3,380	3,331	540	552	543	96	102	92	80	76	79
IV	3,704	3,790	3,705	599	615	601	103	105	102	90	91	89

[1] The three areas are: the western provinces of The Netherlands, including Noord-Holland, Zuid-Holland, and Utrecht; northern and eastern provinces, including Groninger, Friesland, Drenthe, Overyssel, and part of Gelderland; and the southern provinces, *i.e.*, the areas south of the big rivers.

[2] Under 1 year of agc to August 4, 1945 in the western area, to September 1 in the northern and eastern areas, to June 9 in the southern area; thereafter under 2 years of age.

[3] Ages 1-3 years inclusive to August 4, 1945 in western area, to September 1 in northern and eastern areas, to June 9 in southern area; thereafter, ages 2-4 years.

[4] In the western area, ages 4-13 years to June 2, 1945, ages 4-5 years June 3 to August 4 and ages 5-14 years thereafter; in the northern and eastern areas, ages 4-13 years to September 1, 1945; thereafter ages 5-14 years; in the south, ages 4-13 years to June 9 and thereafter ages 5-14 years.

[5] In the western area, ages 14-17 years to June 2, 1945, ages 6-17 years from June 3 to August 4 and ages 15 to 20 years thereafter; in the northern and eastern areas, ages 14-17 years to September 1 and thereafter ages 15-20 years; in the southern area, ages 14-20 years to June 9, and thereafter ages 15-20 years.

PRELIMINARY OBSERVATIONS ON DIURNAL AND OTHER VARIATIONS IN HEMOGLOBIN LEVELS[1]

WALTER WILKINS, M.D., PH.D., AND RUTH BLAKELY, B.S.

IN the course of making hemoglobin studies on large numbers of individuals, primarily school children and teachers, we have carried out therapeutic tests with certain minerals and vitamins on persons having low hemoglobin levels. Adequate control groups always have been set up.

In the first such study set up in Florida, which included 810 school children, we were surprised to find that one subgroup which had received iron for several months showed an average decrease in hemoglobin level of cutaneous blood while the corresponding control group showed an increase. This was rather disconcerting and caused us to check and recheck our procedures rather critically to convince ourselves that these variations were not due to alterations in the technique.

In view of these peculiar results, we rechecked the hemoglobin levels of these two subgroups a few days later, duplicating the previous situation in every way in so far as possible. Results of this test were quite different. As compared with the initial tests done several months before, the control group was essentially unchanged while the group that received iron showed a small average increase in hemoglobin level. No explanation was at hand for this apparent shift in hemoglobin levels of these two groups within a few days.

As part of our attempts at analysis of this situation we tested one small group twice during the *same* day as a preliminary check on duplicability of our technique. The results were still discomforting because differences of as much as 2.5 gms. per 100 cc. were found on some individuals. However, after careful study of the data, it was noted that the lower values, in practically

[1] From Nutrition Investigations and Services, Florida State Board of Health.

every case, were obtained during the afternoon, while the higher values were found in the morning. In view of this apparent instability in hemoglobin levels, with a tendency toward lower values in the afternoon, we reexamined our data on the above-mentioned subgroup receiving iron and its corresponding control group. We found that the initial test on the subgroup receiving iron had been done in the morning and the first recheck in the afternoon while the control group had been tested in the reverse order. The second recheck, however, had been done at the same time of day as the initial test several months before.

Obviously such variations, if disregarded, potentially could have a marked effect on conclusions drawn from therapy in private practice or from therapeutic testing of groups. It seemed incredible that if such instability of hemoglobin values is usual that it was not generally known and was not given prominent consideration in the medical literature on hemoglobin. Also, why was it not mentioned in numerous textbooks on hematology, physiology, and biochemistry? However, Peters and Van Slyke (1) in their QUANTITATIVE CLINICAL CHEMISTRY I, page 549, give two references (2) and (3), and state that the authors of these two papers, after studies on very small groups, "agree in concluding that in a given subject the difference between the lowest and highest hemoglobin content observed during the same day may amount to 20 to 30 per cent of the average content." Peters and Van Slyke conclude: "The fact that a difference of 10 per cent between maximum and minimum hemoglobin content in a day is common, and that greater variations can readily occur, indicates the caution that must be used in interpreting single observations of minor changes or deviations from usual normal levels."

McCarthy and Van Slyke (4) in 1939 studied eighteen young men for hemoglobin changes during the day using the carbon monoxide capacity method. The greatest change reported was 11 per cent of the mean for the day. They state that values were

usually lower during the P.M. than the A.M., but that changes were inconstant. This is in accord with our initial findings.

In 1945 Mole (5) reported an analysis of the data published by McCarthy and Van Slyke. He showed an average fall of about 4 per cent in hemoglobin between 9 A.M. and 11 P.M., but that the changes which occurred between 9 A.M. and 5 P.M. (the working day) were not statistically significant. All of our tests, with the exception of one small group, have been made between 9 A.M. and 5 P.M.

In 1945 Johnson, *et al.* (6) reported that the average hemoglobin value for twelve men was 0.6 gm. lower at 7:30 P.M. than at 7 A.M. on one day, but on two other days the averages at 1 P.M. and 3 P.M. were about the same as at 7 A.M.

The studies mentioned above were on very small groups. The apparent instability of hemoglobin level, if true, could markedly interfere with our program of therapeutic testing unless better understood by us. Therefore, in order to get more specific information on large groups, we made it routine to test each individual both morning and afternoon. On a few individuals we have made tests throughout the course of the day. The results of these tests are described herein.

Comparison of Morning and Afternoon Hemoglobin Values

The results of morning and afternoon hemoglobin determinations on 651 individuals are shown in Table I for six different groups. Most of the tests were done during the usual school day, *i.e.,* between 9 A.M. and 3 P.M. Hemoglobin determinations on these six groups were done with four different "reading" instruments, including two photoelectric colorimeters of the alternating current type, one of the battery type, and one color block with prismatic glass standard. All were calibrated. Within a given group, the same colorimeter was used for the morning and afternoon tests. The same calibrated 20 cu. mm. pipet was used for

A.M. and P.M. tests. The A.M. and P.M. readings of each individual were made in the same glass tube, and were made under as nearly identical conditions as possible. Details of the method have been described by the authors (7).

For each of the six groups the average hemoglobin level is lower in the afternoon than in the morning. This is true for both males and females, and there is little difference by sex for those in the same group. The average differences between morning and afternoon levels vary from 0.5 gm. to 1.0 gm.

Individual differences between morning and afternoon vary widely. While the majority have shown a *drop* in the afternoon value, some individuals have shown a *gain* of as much as 1.6 gms. The numbers in each group with an increase in the afternoon, with no change, and with a decrease in the afternoon are shown

Table 1. Mean hemoglobin values in the morning and in the afternoon for several groups of children and of adults examined in Florida.

Group	Colorimeter Used	Age Range	No. of Subjects		Males			Females		
					Mean Hb.		Diff. A.M.-P.M.	Mean Hb.		Diff. A.M.-P.M.
			M	F	A.M.	P.M.		A.M.	P.M.	
Group A	Battery Lumetron	11-16	72	57	12.9	11.9	1.0	12.4	11.5	0.9
Group B	Glass Standard	6-18	133	129	12.7	12.2	0.5	12.1	11.6	0.5
Group C	Battery Lumetron	6-14[1]	41	56	11.5	11.0	0.5	11.8	11.2	0.6
Group D	Klett-Somerson	Adults	5	27	16.2	15.6	0.6	13.8	13.2	0.6
Group E	A.C. Lumetron	Adults	16	49	14.2	13.2	1.0	12.7	12.0	0.7
Group F	Battery Lumetron	12-19	66		13.4	12.9	0.5			

[1]In addition to eighty-nine children, there are eight adult women in this group.

in Table 2, and the mean difference and standard error of the difference are given. For every group the mean difference is very significant statistically.

Readings for Group A, which is composed of 129 seventh and eighth grade children, were made with a battery type photoelectric colorimeter. Five children showed no change, 11 showed an increase in the afternoon, and 113 showed an afternoon decrease. The greatest increase was 1.6 gms. and the average gain was 0.4 gms. for those who showed an afternoon gain. The greatest afternoon drop was 4.5 gms. Fifty-one children, or 40 per cent, showed a decrease of 1 gm. or more.

Table 2. Distributions of differences between morning and afternoon hemoglobin values for individuals in six different groups examined in Florida.

Difference A.M.-P.M. Grams	Total Subjects		Number of Subjects					
	Number	Per Cent	Group A	Group B	Group C	Group D	Group E	Group F
Total	651	99.9	129	262	97	32	65	66
Higher P.M.								
−1.6-2.0	1	0.2	1					
−1.1-1.5	3	0.5	1	2				
−0.6-1.0	13	2.0	2	7	1		1	2
−0.1-0.5	55	8.4	7	30	8	2	1	7
No Change	38	5.8	5	11	10	2	3	7
Lower P.M.								
+0.1-0.5	198	30.4	19	89	31	14	24	21
+0.6-1.0	204	31.3	50	67	41	8	21	17
+1.1-1.5	95	14.6	22	42	6	5	10	10
+1.6-2.0	27	4.1	9	12			4	2
+2.1-2.5	12	1.8	10	1			1	
+2.6-3.0	2	0.3		1		1		
+3.1-3.5	1	0.2	1					
+4.1-4.5	2	0.3	2					
Mean Difference	+0.63		+0.91	+0.54	+0.45	+0.59	+0.70	+0.48
Standard Error	±0.026		±0.077	±0.038	±0.042	±0.105	±0.068	±0.070
St. Deviation	0.668		0.869	0.609	0.418	0.595	0.546	0.569

The 262 children in Group B were in a consolidated school including grades one through twelve. Finger blood was used and the hemoglobin determinations were made by diluting 20 cu. mm. of blood in a calibrated tube to match a glass standard. As previously reported (7) we have found this method quite satisfactory. We have been primarily interested in testing this method since many health departments throughout the country are using it. On this group the findings are essentially the same as with other groups tested by more refined methods. Eighty per cent of the children in this group showed an afternoon drop in hemoglobin level, the mean drop for the whole group being 0.5 gm. per 100 cc.

Group C is composed of eighty-nine rural school children and eight women teachers and cafeteria workers in the school. The determinations were made with a battery type Lumetron photoelectric colorimeter and 80 per cent of the group showed a decrease in afternoon hemoglobin levels. The mean afternoon drop was 0.5 gm. The mean hemoglobin levels both in the morning and afternoon were rather low according to any standards. About 50 per cent of these children were infested with hookworms.

For Group D, composed of thirty-two school teachers including five men and twenty-seven women, morning and afternoon levels on capillary blood were made with a Klett-Somerson photoelectric colorimeter which had been calibrated to allow thirty minutes for acid hematin color development. All the men except one showed an afternoon drop in hemoglobin level; and their mean drop was 0.7 gm. Two of the women showed no change between morning and afternoon, one showed an increase, and twenty-four showed a decrease. The mean afternoon drop for the entire twenty-seven women was 0.6 gm.

This group differed from the others in that the first test was done one afternoon between two and three o'clock, and the morning test was done on the *following* morning between nine

and ten o'clock. This sequence was used since there had been some question in our minds as to whether the higher levels usually obtained in the morning might not be due partially to the greater apprehension or excitement which most likely would occur at the first test. However, in spite of having done the afternoon test first, the majority of this group showed a lower capillary blood hemoglobin level in the afternoon.

Group E included sixty-five teachers, forty-nine women and sixteen men. The greatest afternoon drop among the men was 2.2 gms. and the mean difference was 1.0 gm. Every man in the group had a lower hemoglobin value in the afternoon. Of the forty-nine women, two showed an increase during the afternoon, three showed no change, and forty-four showed a decrease, the greatest decrease being 2.0 gms. and the mean 0.7 gm. The morning tests were done between 10 and 12 o'clock and the afternoon tests between 2:30 and 4:40. The determinations were made on an alternating current type Lumetron photoelectric colorimeter which was calibrated for a five-minute color-development period for acid hematin.

The sixty-six high-school boys who comprise Group F were members of three football teams and they were tested with a battery type photoelectric colorimeter, as were Groups A and C. These boys were used as subjects for special tests to obtain data on the effect of exercise on hemoglobin levels and these data are discussed below. Values used for Tables 1 and 2 are from determinations made before exercise in the morning and in the afternoon. This Group shows results similar to those obtained for the other Groups.

Hemoglobin Changes Throughout the Day

All of the tests discussed above were done once in the morning and once in the afternoon, the actual times being quite variable. We felt that a small group should be tested several times during

the day using both venous and capillary blood. For this purpose, twenty-four college girls, aged 18 to 26, volunteered for five venipunctures and five finger pricks during a single day. Data for three girls are omitted because one girl missed the late afternoon test, another missed the evening test, and the third fainted immediately after the venous blood sample was drawn at the two o'clock test and her hemoglobin level at this test was much lower than that for any of the other tests. Duplicate or triplicate hemoglobin tests were done on each venous and capillary blood sample. The acid hematin method was used and the readings were made with a battery-type Lumitron photoelectric colorimeter.

Table 3. Average hemoglobin values at different hours of the day for college girls tested five times during one day on both a venous and capillary blood specimen at each test.

Time of Test (Approximate)	Capillary Hemoglobin Mean Gms.	Venous Hemoglobin Mean Gms.
11 Subjects:		
7 A.M.	12.73	12.43
10 A.M.	12.80	12.67
2 P.M.	11.87	11.87
4 P.M.	11.68	11.89
8 P.M.	12.01	11.93
Average for Day	12.22	12.16
10 Subjects:		
8 A.M.	13.15	12.77
12 Noon	12.79	12.83
3 P.M.	12.13	12.12
5 P.M.	11.79	11.74
9:30 P.M.	12.27	12.26
Average for Day	12.43	12.34

The twenty-one girls for whom average hemoglobin values are shown in Table 3 are divided into two groups. For one group, the hours at which tests were made were as follows: between 6:30 and 7:30 A.M. except for one test at about 8 o'clock, between 9:30 and 10:30 A.M., between 1:30 and 2:30 P.M., between 3:30 and 4:30 P.M., and between 7:30 and 8:30 P.M. except for one test at about 9 o'clock; for the second group, the tests were made at the following hours: between 7:30 and 8:30 A.M., between 11:30 A.M. and 12:45 P.M. except for one test at 11 o'clock, be-

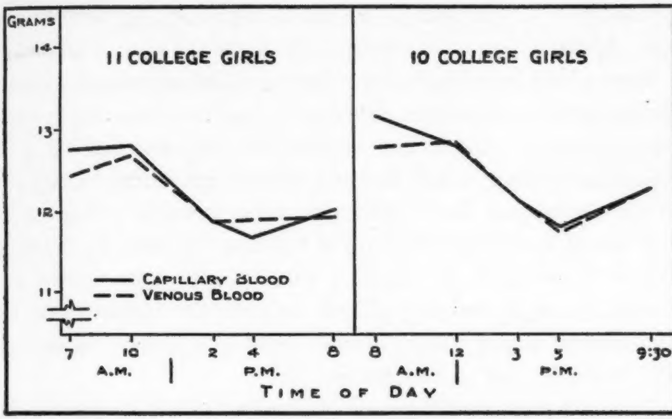

Fig. 1. Diurnal variation in hemoglobin levels of twenty-one college girls tested five times in one day. Average grams of hemoglobin per 100 cc. of whole blood for eleven girls tested at approximately the same hours and for another group of ten girls tested at approximately the same hours.

tween 2:45 and 3:30 P.M., between 4:45 and 5:45 P.M., and between 9 and 10 P.M. except for one test at 8 o'clock. Average values for each group for both venous and capillary blood at the five examinations are shown in Figure 1.

The curves for venous and capillary blood show a distinct tendency to be parallel. However, early in the morning, mean hemoglobin levels for capillary blood were somewhat higher[2] than those for venous blood. The principal drop in hemoglobin values, in both capillary and venous blood, occurred between the 10 and 2 o'clock tests and between noon and 3 P.M. The values continued low or showed a further slight decline in the late afternoon. The average evening values at 8 o'clock on venous blood are the same as in the afternoon, but on capillary blood a slight but significant increase over the 4 o'clock average is shown

[2] For the 105 hemoglobin determinations on both venous and capillary blood, the mean difference is 0.07 ± 0.04 gm., and the difference is not significant. At the early morning test, much higher capillary than venous values were obtained for three subjects, the differences being 1.3, 1.4, and 1.8 gms.; no other differences exceeded 0.9 gm.

(P. is .02-.05). The average values at 9:30 P.M. on both venous and capillary blood are significantly higher than at 5 o'clock.

Most of the individual curves corresponded in general with the group pattern. Six of the eleven girls had their minimum capillary value at 4 o'clock, four at 2 o'clock, and one had the same minimum value at 2 and also at 4 o'clock; on venous blood, nine of the eleven girls had a minimum value at either 2 or 4 o'clock but two of them had a minimum value at 8 o'clock. In the other group of ten girls the capillary value was at a minimum at 5 o'clock for eight and at 3 o'clock for two; the venous value was at a minimum at 5 o'clock also for eight, at 3 o'clock for one girl and at 8 A.M. and 10 P.M. for one girl.

The five greatest differences in capillary blood during the day were 1.6, 2.0, 2.0, 2.1, and 2.9 gms. The five greatest drops in venous blood hemoglobin were 1.5, 1.6, 1.7, 1.8, and 2.1 gms. All represented differences between morning and afternoon. These changes in both capillary and venous blood show very definitely that, under the conditions of this experiment, blood hemoglobin is quite variable during the day. One hemoglobin determination on an individual, even when carefully and accurately made, may give results quite different from another determination made at some other time.

Five determinations during the day, of course, greatly increase the chance of getting blood samples near the maximum and minimum hemoglobin levels as compared with taking only two samples during the day. This would account for the higher percentage of the twenty-one college girls showing greater changes in hemoglobin levels during the day than did any other group. It seems likely that actual differences between the morning maximum and the afternoon minimum may be greater than shown by the mean differences *observed* when only two tests are done, since the chances are against getting the two samples at the exact times that these extremes occur in the blood stream.

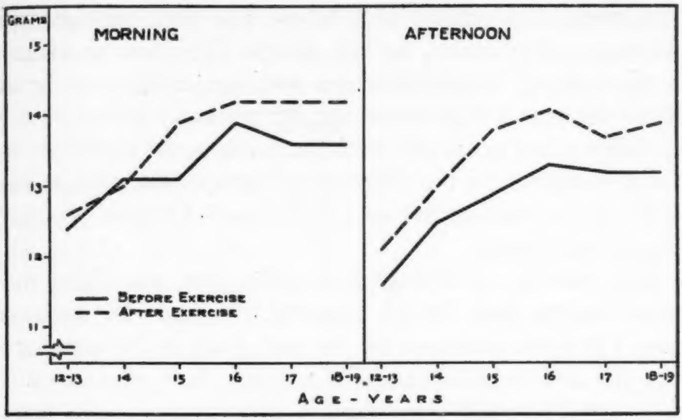

Fig. 2. Average hemoglobin levels before and after exercise for tests made in the morning and again in the afternoon on sixty-six high school boys classified according to age.

Effect of Several Factors on Hemoglobin Level

In order to check certain factors which are thought or known to produce fleeting changes in hemoglobin level, on limited groups we have recorded pulse rates at the time the blood was taken, made tests before and after exercise, and tested individuals who skipped the mid-day meal.

"Excitement." We have observed repeatedly that individuals coming up for blood tests, although attempting to appear calm, actually may be quite excited. Excitement is said to increase the blood hemoglobin level ((1), p. 557). To check this on a larger scale, we took pulse rates on several hundred children and adults at the time the morning and afternoon blood specimens were being taken. In a typical group of 361 children, pulse rates averaged 104 both in the morning and in the afternoon. There seemed to be no correlation between pulse rate as such and temporary hemoglobin level.

"Exercise." Figure 2 shows the finger blood hemoglobin levels

of sixty-six high school boys before and after exercise, both morning and afternoon, by age groups. There was an increase in the "resting" hemoglobin level with age, which is to be expected for boys of high school age. As previously shown (Group F, Tables 1 and 2), resting levels are lower in the afternoon and this is consistent for the different age groups. The exercise consisted of a ten-minute trot on a cinder track followed by a one-minute rapid sprint.

After exercise, the average hemoglobin level was higher than before exercise both for the morning tests and the afternoon tests. The mean difference for the total group in the morning is 0.39 gm. and in the afternoon is 0.66 gm.; both of these differences are statistically significant. A greater elevation in hemoglobin after exercise for the afternoon tests is consistent for each age group, and the greater increase in the afternoon than in the morning is statistically significant.

The distribution of individual differences between resting

Table 4. Individual differences between hemoglobin values obtained before and after exercise from tests made in the morning and the afternoon on sixty-six boys ages 12-19 years.

Difference (After Ex.-Resting) Hb. Gms.	Morning Tests		Afternoon Tests	
	Number	Per Cent	Number	Per Cent
Total	66	99.9	66	100.0
−0.6-1.0	2	3.0	1	1.5
−0.1-0.5	8	12.1	2	3.0
No Change	10	15.2	4	6.1
+0.1-0.5	22	33.3	17	25.8
+0.6-1.0	20	30.3	33	50.0
+1.1-1.5	2	3.0	7	10.6
+1.6-2.0	0		1	1.5
+2.1-2.5	2	3.0	1	1.5
Mean Difference	+0.39		+0.66	
St. Error	±0.070		±0.059	
St. Deviation	0.566		0.479	

hemoglobin values and after exercise values is shown in Table 4. In the morning ten subjects showed a drop after exercise and ten showed no change, leaving forty-six, or 70 per cent, that increased. In the afternoon, only three cases showed a decrease after exercise, four showed no change, and fifty-nine, or 89 per cent, showed an increase. The maximum increase in the morning was 2.4 gms. and in the afternoon was 2.5 gms.

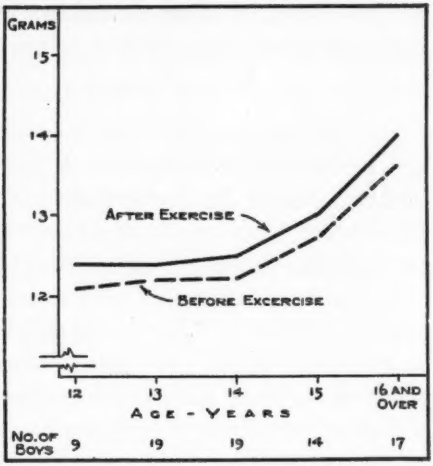

Fig. 3. Average hemoglobin levels before and after exercise for seventy-eight high school boys classified according to age. Grams of hemoglobin per 100 cc. of venous blood.

Hemoglobin elevations of *venous* blood following the type of exercise mentioned above are shown in Figure 3 for seventy-eight boys 12 years of age or older. At each age, the average hemoglobin level after exercise is higher than before exercise. The increase with exercise is 0.2 to 0.5 gm. for the different age groups.

"Effect of Mid-Day Meal." We have not as yet studied this factor on a large scale but have merely observed that individuals who skipped the mid-day meal, for one reason or another, showed no trend in hemoglobin values different from those who had a large one. This is now being studied on larger groups.

"Temperature." Most of our work has been done either in school buildings or in a trailer-laboratory. Thus it has not been possible to control the temperature. Study of our data seems to show a slight trend toward less afternoon drop in hemoglobin

level when the weather was unusually cool in the afternoon. This, however, is a very preliminary observation. Plans are under way to study this more specifically on a group of college students. We have arranged to use the facilities of a cold storage plant having large rooms maintained at different temperatures.

Summary

Data on morning and afternoon hemoglobin determinations are presented for 651 adults and children. These show appreciable variation during the day and the majority of individuals tested show lower levels in the afternoon. This was found for determinations on venous and on capillary blood.

Twenty-one college girls were tested five times during the day from 7 A.M. to 10 P.M. for hemoglobin values on both venous and capillary blood. The highest values obtained were in the morning for every subject and the lowest were between 2 and 5 o'clock in the afternoon with the exception of three subjects for whom venous values, but not capillary, were lowest at 8 to 10 P.M. There was a significant tendency for values to rise in the evening above the afternoon minimum value.

Aided by grants from the Milbank Memorial Fund, the Williams Waterman Fund for the Combat of Dietary Diseases, and the Nutrition Foundation.

References

1. Peters, John P. and Van Slyke, D. D.: Quantitative Clinical Chemistry, I. Interpretations. Baltimore, The Williams & Wilkins Company, 1931, p. 549.

2. Dreyer, G.; Bazett, H. C.; and Pierce, H. F.: Diurnal Variations in the Hemoglobin Content of the Blood. *Lancet*, 1920, 2, p. 588.

3. Rabinovitch, I. M.: Variations of the Percentage of the Hemoglobin in Man During the Day. *Journal of Laboratory and Clinical Medicine*, 1923-1924, 9, p. 120.

4. McCarthy, E. F. and Van Slyke, D. D.: Hemoglobin Diurnal Variation. *Journal of Biological Chemistry*, 1939, 128, pp. 567-572.

5. Mole, R. H.: Diurnal and Sampling Variations in the Determination of Hemoglobin. *Journal of Physiology*, London, June, 1945, 104, pp. 1-5.

6. Johnson, R. E.; Henderson, C.; Robinson, P. F.; and Consolazio, F. C.: Comparative Merits of Fasting Specimens, Random Specimens, and Oral Loading Tests in Field Nutritional Surveys. *Journal of Nutrition*, August, 1945, 30, No. 2, pp. 89-98.

7. Wilkins, Walter and Blakely, Ruth: Rapid Hemoglobin Determinations on School Children. *Journal of School Health* (in Press).

HEMOGLOBIN VARIATIONS FOR WOMEN ON IRON THERAPY FOR THIRTY-ONE MONTHS[1]

Dorothy G. Wiehl and H. D. Kruse, M.D.

An investigation of the effect of prolonged iron therapy on hemoglobin levels of women with slightly subnormal values at an initial examination was undertaken in April, 1943. The increase in the hemoglobin level and the individual variation in hemoglobin values shown by determinations at approximately six-month intervals over a two and one-half year period on therapy have been studied. A comparison is made of the results obtained with reduced iron and with feosol.

For a control group of women who received no iron therapy, hemoglobin values were obtained at the same intervals over the two and one-half years. The long-time and periodic individual changes in hemoglobin values for this group also are presented.

Description of Therapy and Control Groups

The women who participated in this investigation were nurses employed by a visiting nurse agency in New York City. Their ages ranged from 18 to 58 years, but about three-fourths of the group were between ages 25 and 39 years at the initial examination in October, 1942. Of 107 women examined initially, eleven were colored; and data for the two groups are considered separately in the following analysis.

On the basis of the hemoglobin values obtained in October, 1942, the therapy subjects were selected. All persons with values less than 11.5 gms. were placed in the therapy group. These included seven white and three colored women, of whom three white and two colored women were given reduced iron and the others were given feosol. Another ten subjects for therapy were selected at random from those having hemoglobin values be-

[1] From the Milbank Memorial Fund, New York.

tween 11.5 and 11.9 gms. inclusive. The total group for reduced iron therapy included seven white and four colored women; the feosol group included eight white women and one colored woman.

Since approximately six months elapsed before therapy was distributed, the hemoglobin levels of some of the therapy subjects may have been considerably higher or lower at the time therapy was begun than at the initial examination. Thus, the therapy group may be described as comprising persons who at a previous examination had moderately or slightly subnormal hemoglobin values. Regardless of the spontaneous changes that may have occurred in the six-month interval before beginning therapy, the hemoglobin levels following one to two and a half years of therapy are of interest.

All the women used as "controls" in this Study of iron therapy and the total nontherapy group were subjects during the two and a half years for an investigation of the effect of vitamin therapy on selected specific signs. They were divided into five groups and subjects in each group received only one vitamin. An analysis of the hemoglobin values for the five groups indicated no significant difference among them with respect to hemoglobin values at any examination.

Methods of the Study

Subjects on reduced iron and those receiving feosol were given approximately the same amount of iron, 60 and 63 mgs. per day, respectively. The reduced iron was in 15 mg. tablets which were to be taken four times a day; the daily dosage of feosol was in a single tablet. Therapy for a two-month period was distributed to the subjects regularly. There was no way to observe whether the therapy was taken regularly, but the subjects had volunteered and were extremely interested. Although undoubtedly some occasionally missed taking their therapy, it is believed that any marked irregularity or interruption in taking therapy

would have been reported by those who remained in the Study and returned for reexaminations.

The first reexamination was made in July, 1943, or ten to twelve weeks after therapy was started and about nine months after the initial examination had been carried out. Later reexaminations were at approximately the following intervals after therapy started in April, 1943: 7 months, 12 months, 19 months, 25 months, and 31 months. Over so long a period it was inevitable that the number remaining in the Study would gradually diminish, especially since many of these nurses left to enlist in military service. Details of the changes in numbers will be given in the analysis, but it may be mentioned here that only one of the twenty persons on either form of iron therapy left the Study before completing one year of therapy.

The hemoglobin determinations were made on 20 cu. mm. of finger-prick blood by the Evelyn method for photoelectric determination of oxyhemoglobin. The same Evelyn photoelectric colorimeter was used for all determinations. Average hemoglobin values for two blood samples, one from the left and one from the right hand, are used throughout the Study except for the initial examination when only one determination was made for each person. Two technicians made all the hemoglobin determinations and, with a very few exceptions, one technician made all determinations for a given examination period. Hemoglobin values were computed to the nearest 0.1 gm.

Initial Hemoglobin Findings

The initial hemoglobin levels of the 107 women examined in October, 1942 are shown in Table 1 by color and age of the subjects. The average hemoglobin value for the ninety-six white women was 12.67 gms. and for the eleven colored women was 11.87 gms. Two white women and no colored women had less than 10.0 gms. of hemoglobin per 100 ml. of blood; seven white

women (7.3 per cent) and three colored women (27.3 per cent) had less than 11.5 gms. of hemoglobin. The range for hemoglobin values was wide and two white women had values over 15 gms. (15.2 and 15.3 gms.), but the maximum for the colored women was 13.6 gms. The average hemoglobin level for the eleven colored women is significantly lower than would be expected if these women were a random sample of the total 107 women examined.

There is an apparent upward trend in the average hemoglobin values as age increased for the white women, with the striking exception of the age group 40-49 for which the average hemoglobin value is the lowest of any age group although only very

Table 1. Hemoglobin values for ninety-six white women according to age and for eleven colored women at initial examination in October, 1942.

Hemoglobin Level Gms.	Number of White Women by Age Groups						Colored Women
	All Ages	18-29[1] Years	30-34 Years	35-39 Years	40-49 Years	50-59 Years	All Ages[2]
Total	96	30	23	26	13	4	11
8.18	1	1					
9.39	1		1				
10.0-10.9	3	2			1		2
11.0-11.4	2	1	1				1
11.5-11.9	20	10	3	4	3		4
12.0-12.4	16	4	6	3	3		2
12.5-12.9	16	3	4	6	3		
13.0-13.4	12	3	2	5	1	1	1
13.5-13.9	15	2	3	5	2	3	1
14.0-14.4	6	2	3	1			
14.5-14.9	2	1		1			
15.0+	2	1		1			
Mean	12.665	12.360	12.625	13.059	12.331	13.705	11.871
St. Error	±.118	±.258	±.229	±.176	±.243	±.126	±.296
St. Deviation	1.15	1.41	1.10	.897	.875	.252	.981

[1]Five women were under 25 years of age and of these one had a hemoglobin level less than 12.0 gms. (11.7 gms.).

[2]Numbers of colored women by age were: 2 under 30 years; 2 aged 30-39 years; 3 aged 40-49 years; and 2 aged 50-59 years.

slightly lower than at ages 18 to 29 years. However, in each age group the variation in hemoglobin values is great and an analysis of variance for the three age groups under 40 years indicates that differences in the means for these three groups are within limits expected as a result of random sampling. Also, the average for the thirteen persons in the age group 40-49 years does not differ significantly from the total group under 40 years of age. Thus, these data give no evidence of significant age variations in hemoglobin values.

Adjustments in Reexamination Values for Technical Variations in Hemoglobin Determinations

Before the reexamination data were analyzed for evidence of effects of iron therapy, technical and error variation in the determinations were studied. Results of this study of the accuracy of the determinations have been reported (1) in detail. Comparison of the hemoglobin values obtained for nontherapy subjects at the first six of the seven examination periods indicated approximately constant average values at four periods and higher average values at two periods, the second and sixth examinations. Both of the higher averages were obtained by one of the technicians (C). On the basis of these findings and a special comparative study of the technicians made since the publication of the report, it was concluded that this technician had not maintained a constant technique and had a tendency to obtain higher values than the other technician. Presumably this is due to a slightly different standard of measuring the blood sample. This technical bias introduced into the serial examinations has necessitated some adjustment in the data for purposes of evaluating individual changes.

To adjust the relatively higher determinations obtained at the second and sixth examinations so that the average difference would be eliminated, a deduction of 0.5 gm. was made from

every individual determination in these periods. Although this adjustment removes the average difference, which, it is believed, was a fairly constant bias[2] in these periods, the periodic changes in individual values undoubtedly are affected by a residual variation due to the fact that the bias was not entirely constant.

A slight adjustment in individual determinations obtained in the third examination period by the other technician (B) was made in order to bring the average for the period more closely into line with the constant average used as a base line. Values in the third period were increased 0.1 gm. This adjustment makes allowance for significantly lower values obtained on left than on right-hand blood specimens in this period.[3]

All individual hemoglobin values in the seventh period were adjusted by reducing each value by 0.24 gm. The average for non-therapy subjects in this period was higher by this amount than that for the same subjects examined previously by the same technician. No explanation for a shift in the level of the determinations in the seventh period (made by technician B) has been identified, but it has seemed best to maintain the general average for this period.

In summary, the values used for the first, fourth, and fifth examinations are the original determinations obtained by the technicians. Adjusted values[4] are used for the other four examinations as follows: values at the second and sixth examinations are *reduced* 0.5 gm.; determinations at the third examination are *increased* 0.1 gm.; and those at the seventh examination are *re-*

[2] In the periods in which the technician obtained relatively high values, the error variation for his duplicate determinations (right and left hands) was about the same as in the period in which he obtained lower values; and the error variation for this technician was very similar to that for the other technician. *See* (1).

[3] In the previous report (1), this bias is discussed. The mean difference for the right and left-hand specimens was .16 gm. and it is thought to be due to imperfect drying of the pipet between specimens. The mean difference in other periods varied from .02 to .05 gm.

[4] For computation of the amounts to adjust values at the different periods, average values at different periods for the *same* individuals were used. Mean values for selected groups or for different individuals continue to vary somewhat at various periods.

duced 0.24 gm. It is unfortunate that these adjustments were necessary, and it may seem that they have complicated the analyses presented in this evaluation of hemoglobin changes. However, the arbitrary elimination of periodic changes resulting from a technical bias permits the changes due to other factors to be seen more clearly. Since the adjustment is constant for every individual in any period, measurements of variation within the period are not affected, and means for special groups of subjects are affected equally so that differences between them are not affected.

Hemoglobin Changes After Iron Therapy

Comparison of Reduced Iron and Feosol. Data on the hemoglobin values obtained at various intervals from 10-12 weeks to 31 months after beginning therapy are shown in Table 2 for the seven white women taking reduced iron and the eight white women taking feosol. For each group the average hemoglobin level and standard error of the average and the range of values

Table 2. Hemoglobin values (grams per 100 ml.) for white and colored women on iron therapy for two and a half years.

Color Group and Period of Therapy	Reduced Iron			Feosol			Iron or Feosol	
	Number	Mean and St. Error	Range	Number	Mean and St. Error	Range	Number	Mean and St. Error
White								
I. Initial Exam.	7	11.16±.353	9.4-11.9	8	10.93±.444	8.2-11.9	15	11.03±.280
II. 10-12 Weeks	5	12.60±.444	10.9-13.5	8	12.58±.209	11.8-13.7	13	12.58±.202
III. 7 Months	6	12.55±.565	11.1-14.4	8	12.99±.264	11.9-14.1	14	12.80±.279
IV. 12 Months	6	12.30±.137	11.9-12.7	8	12.69±.330	11.3-14.4	14	12.52±.199
V. 19 Months	5	12.72±.271	11.9-13.6	4	12.68	12.5-12.9	9	12.70±.147
VI. 25 Months	4	12.48	11.1-13.6	3	12.10	11.5-12.5	7	12.31±.309
VII. 31 Months	3	12.73	11.9-13.3	3	12.80	12.6-13.0	6	12.77±.198
Colored								
I. Initial Exam.	4	11.13	10.0-11.9	1	11.2		5[1]	11.14±.336
II. 10-12 Weeks	4	11.73	10.8-13.0	1	10.6		5	11.50±.458
III. 7 Months	3	12.53	11.8-13.2	1	11.1		4	12.18±.459
IV. 12 Months	4	11.93	11.3-12.3	1	12.6		5	12.06±.220
V. 19 Months	3	12.53	12.0-13.5	1	12.7		4	12.58±.345
VI. 25 Months	3	12.43	11.7-13.7	1	10.9		4	12.05±.591
VII. 31 Months	3	12.43	10.9-13.3	1	12.3		4	12.40±.545

[1]For the four women who continued therapy for 31 months, the average hemoglobin was 11.43±.229 gms. at the initial examination.

is shown. It will be noted that not every case was reexamined at each period. After 10 to 12 weeks of therapy, the two groups had almost identical average values, the means being 12.60 and 12.58 gms.[5] The maximum value obtained for any person also was about equal for the two groups, being 13.5 gms. for those on reduced iron and 13.7 gms. for those on feosol; but the minimum values differed and one subject taking reduced iron (this person had an initial value of 9.4 gms.) still had only 10.9 gms. of hemoglobin per 100 ml. compared with a minimum finding of 11.8 gms. among the feosol cases which included one with an initial value of 8.2 gms. There was, however, no real difference between these two therapy groups after 10-12 weeks of therapy.

Only small differences which are not significant statistically are found for the mean hemoglobin values for the two therapy groups at every reeexamination period throughout the 31 months. After the first 12 months, the numbers of persons continuing on therapy decreased and at the examination after 31 months of therapy only three cases remained in each group. No significant further increase in hemoglobin values is indicated after the first 12 weeks for either group. The general level remained static and there was no difference between the groups in the occurrence of high individual hemoglobin values or of low values. For these few subjects the response to reduced iron and to feosol over the 31 months was nearly identical.

Periodic Variation. Although the average level remained fairly constant, individual values varied to a considerable degree from one period to another. Some examples of individual periodic variation while on therapy may be cited. The subject with the lowest initial hemoglobin value in the series (8.2 gms.) had reached 12.0 gms. after 12 weeks of therapy and at the five later examinations her hemoglobin values varied from 12.3 to 12.9 gms. which

[5] These averages after 10-12 weeks of therapy are significantly higher than the averages for the initial examination, but the increase cannot be attributed to the therapy since the initial values were obtained six months before therapy started.

probably is within the limits of accidental variation. The subject with the next lowest initial hemoglobin value (9.4 gms.) showed a much slower increase in hemoglobin values; at the second, third, and fourth examinations her values were 10.9, 11.1, 11.9 gms., respectively, and at the fifth examination (19 months on therapy) the value rose to 13.6 gms. but six months later it had dropped again to 11.1 gms. Another case with an initial hemoglobin value of 10.9 had a value of 13.7 gms. after 12 weeks of therapy and 14.1 gms. after 7 months of therapy but after 12 months of therapy her hemoglobin value declined to 12.1 gms. A subject with a hemoglobin value of 14.4 gms. after 7 months of therapy had a value of 11.9 gms. at the next two examinations. Thus, the changes in hemoglobin values obtained at intervals over many months suggest that even on continuous therapy a number of these women failed to maintain moderately good hemoglobin levels.

A statistical measure of this variation in individual hemoglobin values from period to period is given in Table 3. For eleven women who were reexamined in the second, third, and fourth periods, *i.e.,* after 10-12 weeks, 7 months, and 12 months of therapy, the variation in the three hemoglobin determinations from their individual mean levels for these periods gives an average standard deviation of .70 gm. For six women who continued therapy for the entire 31 months, the standard deviation for their individual variation in values obtained after 19, 25, and 31 months is .67 gm. Of the six women who remained on therapy for 31 months, five received all six reexaminations. The standard deviation for their individual periodic variation for six examinations is .62 gm.

The analysis in Table 3 also shows that the eleven women on therapy for one year who were reexamined three times in this year did not differ with respect to their mean hemoglobin levels more than might be expected from chance in view of their large

individual periodic variation. The average hemoglobin level for this group for these three reexaminations was 12.65 gms., and the individual mean values ranged from 11.30 to 13.30 gms. Similarly, the six women on therapy for 31 months did not differ significantly in the last three reexaminations. Their mean hemoglobin level after 19 to 31 months of therapy was 12.64 gms., and the range in individual means was 12.20 to 13.07 gms. However, the individual mean values for the five women with all six post-therapy reexaminations did differ significantly and suggest that there was some tendency for the women to differ in their response to therapy. For the six examinations in a 28-month period, the average hemoglobin level of the five women was 12.50 gms. and the range in individual means was 11.75 to 12.95 gms.

Hemoglobin Changes for Colored Women on Therapy. Hemoglobin values for the five colored women who received therapy are shown in Table 2. Since only one colored woman received feosol and since there was no difference in the therapeutic re-

Table 3. Analysis of variance for white therapy subjects showing mean periodic individual variation in hemoglobin values and significance of differences among individual mean levels for several reexaminations.

Examination Periods and Source of Variation	Degrees of Freedom	Variance	Variance Ratio (F)	Probability	Standard Deviation for Individual Variation
Periods II, III, and IV					
Among Person Means	10	.9882	2.00	>.05	
Individual Periodic Var.	22	.4936			.703
Periods V, VI, and VII					
Among Person Means	5	.3286	*		
Individual Periodic Var.	12	.4483			.670
Periods II-VII					
Among Person Means	4	1.3320	3.42	.01-.05	
Individual Periodic Var.	25	.3897			.624

*Individual periodic variation greater than variance for person means.

sponse to reduced iron and to feosol for white women, only the results for the total colored group will be considered. After 10 to 12 weeks of therapy, the average hemoglobin value for the five colored women was 11.50 gms. and not significantly higher than the average value at the initial examination about 9 months previous. After 7 months of therapy, the average hemoglobin value for the four colored women who were reexamined had risen to 12.18 gms. and thereafter the average value for this group showed no consistent increase although at 19 months after therapy a maximum average of 12.58 gms. was obtained. Only the average for this period is significantly higher than the initial average of 11.43 gms. for the same four women. Thus, there is evidence of only slight improvement among the colored women.

At every examination after therapy, the average hemoglobin value for the four or five colored women was somewhat lower than the average value for white women at the same period. This difference is statistically significant[6] at the second examination (10 to 12 weeks after beginning therapy) but it is not significant at any other period. The experience with this small group of colored women suggests that their improvement in hemoglobin levels on therapy was less than that for whites. However, the colored women, as the white women, varied greatly in their response and a definite conclusion that the difference observed here is characteristic or typical is not warranted. Experience with larger numbers of women is needed.

Therapy and Control Subjects

In order to evaluate the improvement in hemoglobin values shown by the white[7] women taking iron therapy, the values ob-

[6] At the second examination, the difference between means (white-colored) is +1.08 gms., the standard error of the difference is ±.427, and P is .01-.05. The maximum difference at any other period (third) is +.625 ±.578 gm. and is not significant. Furthermore, analysis of variance for periods III and IV indicated no significant difference in means for color groups and a similar result was obtained when periods V-VII are combined.

[7] Comparison with a control group is limited to the white women although the colored (Continued on page 384)

Examination Period and Group	Number	Mean Hb. Gms. and St. Error	Standard Deviation	Control-Therapy, Difference and St. Error
II *Therapy 10-12 Weeks*				
Therapy—Total	13	12.58±.202	.730	−.113±.220
" —Initial Hb. 11.5	6	12.37±.407	.997	+.105±.298
" " " 11.5-11.9	7	12.77±.146	.386	−.300±.172
Control " " 11.5-12.0	14	12.47±.097	.365	
III *Therapy 7 Months*				
Therapy—Total	14	12.80±.279	1.042	−.120±.425
" —Initial Hb. 11.5	7	12.27±.422	1.116	+.409±.517
" " " 11.5-11.9	7	13.33±.255	.675	−.649±.437
Control " " 11.5-12.0	10	12.68±.317	1.003	
IV *Therapy 12 Months*				
Therapy—Total	14	12.52±.199	.743	+.115±.357
" —Initial Hb. 11.5	6	12.55±.219	.536	+.086±.460
" " " 11.5-11.9	8	12.50±.320	.906	+.136±.460
Control " " 11.5-12.0	11	12.64±.315	1.044	
V *Therapy 19 Months*				
Therapy—Total	9	12.70±.147	.442	+.030±.201
" —Initial Hb. 11.5	4	12.88		
" " " 11.5-11.9	5	12.56		
Control	10	12.73±.137	.432	
VI *Therapy 25 Months*				
Therapy—Total	7	12.31±.309	.818	+.273±.416
Control	8	12.59±.279	.790	
VII *Therapy 31 Months*				
Therapy—Total	6	12.77±.198	.484	+.393±.269
Control	5	13.16±.175	.391	

Table 4. Comparison of hemoglobin values of white women taking iron therapy with those of a nontherapy control group initially having low hemoglobin values.

tained for this group over the two and one-half year period are compared in Table 4 with the hemoglobin values obtained at the

and white groups on therapy did not differ significantly with respect to their hemoglobin values except at the second examination. Since the averages for the colored group were consistently somewhat lower than those for the white group, inclusion of the colored therapy subjects would reduce the average values for therapy subjects and minimize any advantage shown for them. Comparison of the more homogenous groups of white women seems preferable.

same examination periods for a group of white women who did not receive any iron therapy and who had hemoglobin values at the initial examination of 11.5 to 12.0 gms. This latter group will be designated as a control group.

Since approximately half of the white women who received therapy had hemoglobin values of less than 11.5 gms. at the initial examination, data for these women and for those with 11.5-11.9 gms. are shown separately in Table 4. After 10 to 12 weeks of therapy and about 9 months after the initial examination, subjects with the lower initial hemoglobin values had, on the average, lower values than those with higher initial values but the difference (.40 gm.) is not statistically significant. At the third examination the superiority of the group with higher initial values increased to 1.06 gms. but again the difference is not significant. At later reexamination the differences in the average hemoglobin levels for these two therapy groups were small.

The difference between the average hemoglobin value for the control group and the therapy group at each of the six post-therapy examinations is shown in Table 4. At no examination is the difference statistically significant. The control group had an average hemoglobin value slightly lower than the therapy group at the second and third examinations (.11 and .12 gm.) and thereafter their average value was slightly higher (.03 to .39 gm.). Thus, there is no evidence that these women who took iron therapy for two and a half years improved their hemoglobin values any more than the spontaneous improvement that occurred among women not taking therapy during the same period.

Reexamination Hemoglobin Levels for Women Classified According to Initial Values

Since the average hemoglobin level for the control group (initial values 11.5-12.0 gms.) remained at a fairly constant level

Table 5. Comparison of hemoglobin values at seven examinations over a three-year period for three groups of white women whose hemoglobin values at first examination were: A, 11.5-12.4 gms.; B, 12.5-13.4 gms.; and C, 13.5-15.3 gms.

Examination and Group by First Hb. Value	Number	Mean Hb. Gms. and St. Error	Standard Deviation
I *October, 1942*			
Total	79	12.94 ±.099	.877
A—Low Hb.	25	12.04 ±.053	.279
B—Intermediate Hb.	27	12.95 ±.064	.331
C—High Hb.	24	13.99 ±.106	.518
II *9 Months Later*			
Total	72	12.95 ±.093	.792
A	24	12.46 ±.091	.446
B	24	12.87 ±.162	.794
C	24	13.53 ±.143	.703
III *13 Months Later*			
Total	67	12.99 ±.122	.997
A	23	12.61 ±.174	.835
B	23	13.12 ±.189	.909
C	21	13.26 ±.253	1.161
IV *18 Months Later*			
Total	67	12.97 ±.116	.947
A	22	12.56 ±.197	.924
B	24	12.97 ±.168	.824
C	21	13.39 ±.209	.957
V *25 Months Later*			
Total	53	13.01 ±.078	.568
A	19	12.81 ±.094	.409
B	21	13.04 ±.119	.547
C	13	13.27 ±.197	.711
VI *31 Months Later*			
Total	43	13.07 ±.091	.598
A	16	12.79 ±.172	.688
B	15	13.13 ±.134	.519
C	12	13.35 ±.120	.417
VII *37 Months Later*			
Total	39	13.10 ±.101	.630
A	12	12.85 ±.210	.727
B	15	13.30 ±.158	.612
C	12	13.11 ±.143	.494

following an increase within the nine months between the initial and second examination, it is of interest to examine the changes in averages for women with higher initial hemoglobin levels. All nontherapy white women, including the "controls," were classified according to their initial hemoglobin value in one of three groups as follows: A, low initial value, 11.5-12.4 gms.; B, intermediate initial value, 12.5-13.4 gms.; and C, high initial value, 13.5-15.3 gms. For each group the mean and standard deviation of individual values at each of the seven examinations over approximately three years are shown in Table 5.

For the low group (A), average hemoglobin values at each examination after the first vary from 12.46 to 12.85 gms. and are about the same as those for the control group which forms approximately one-half of Group A. There is a definite increase from the initial average value of 12.04 gms. to 12.61 gms. at the third examination about thirteen months after the initial examination, and thereafter changes are not significant. At every examination the average for this group is lower than the averages for groups B and C.

For the intermediate group (B) the average hemoglobin level continues to be in between the average for group A and the average for group C at every examination except the last when it is slightly higher, but not significantly higher, than the average for the high initial value group. At the initial examination the average hemoglobin for group B is 12.95 gms. and for the other six examinations it ranges from 12.87 to 13.30 gms. The average value for group C, high initial values, decreased from 13.99 gms. at the first examination to 13.53 gms. at the second and 13.26 gms. at the third and thereafter remained fairly constant.

In Table 6 the significance of the variation among mean hemoglobin levels for the three groups at each examination period is shown. The means, of course, are very significantly different at the first examination on which the groups are selected. The

Table 6. Significance of variation in mean hemoglobin values at periodic reexaminations over a period of three years for three groups of white women classified at initial examination into those with low, intermediate, and high hemoglobin levels.

Examination Periods and Source of Variation	Degrees of Freedom	Variance	Variance Ratio (F)	Probability
I *Initial Examination*				
Means of Groups	2	24.4357	167.02	<.001
Within Groups	76	.1463		
II *9 Months Later*				
Means of Groups	2	7.0588	16.01	<.001
Within Groups	69	.4409		
III *13 Months Later*				
Means of Groups	2	2.5831	2.73	>.05
Within Groups	64	.9446		
IV *18 Months Later*				
Means of Groups	2	3.6732	4.53	.01-.05
Within Groups	64	.8102		
V *25 Months Later*				
Means of Groups	2	.8461	2.81	>.05
Within Groups	50	.3014		
VI *31 Months Later*				
Means of Groups	2	1.1109	3.47	.01-.05
Within Groups	40	.3198		
VII *37 Months Later*				
Means of Groups	2	.6753	1.77	>.05
Within Groups	36	.3816		
	ANALYSIS OF VARIANCE FOR LOW GROUP COMPARED WITH INTERMEDIATE AND HIGH GROUPS COMBINED			
III *13 Months Later*				
Between Means	1	4.9648	5.32	.01-.05
Within Groups	65	.9332		
IV *18 Months Later*				
Between Means	1	5.4130	6.54	.01-.05
Within Groups	65	.8275		
V *25 Months Later*				
Between Means	1	1.2810	4.22	.01-.05
Within Groups	51	.3035		
VI *31 Months Later*				
Between Means	1	1.9087	5.97	.01-.05
Within Groups	41	.3197		
VII *37 Months Later*				
Between Means	1	1.1057	2.93	>.05
Within Groups	37	.3779		

groups continued to differ very significantly at the second examination but were not significantly different at the third. For the remaining four examinations the means differ significantly at two examinations and do not differ significantly at two examinations.

Since the difference between averages for those with intermediate and with high initial values is small after the second reexamination, these two groups were combined and compared with the low hemoglobin group. As shown in Table 6, the low group had a significantly lower average at each examination except the last.

In general, therefore, these data indicate that women with relatively low hemoglobin values at one examination showed a definite tendency to continue over a three-year period to have relatively low values although some improvement in their hemoglobin occurred. Women with relatively high hemoglobin values at one period continued, on the average, to have higher values for about nine months, but over a longer period their superiority diminished and their values became similar to those for a group with intermediate or slightly lower hemoglobin values at the initial examination.

These results at successive examinations for women in the low third of the distribution of hemoglobin values at an initial examination indicate that in the majority of cases lower than average hemoglobin was a chronic or intermittently recurring condition over a period of three years.

Periodic Individual Variation in Hemoglobin Values

Although there was a significant tendency for women with relatively low hemoglobin values to continue to have low values, changes of considerable magnitude in individual values from one examination to another occurred for many persons in this group as well as for those in the higher initial level groups. An analysis

Table 7. Periodic individual variation in hemoglobin values obtained at approximately six-month intervals over a two and a half year period for white women and for three subgroups according to hemoglobin values at a previous initial examination. Analysis of variance for variation among individual means and for individual values from their means.

Examination Periods and Source of Variation	Number of Cases	Mean Hb. (Gms.)	Analysis of Variance: Degrees of Freedom	Analysis of Variance: Variance	Analysis of Variance: Variance Ratio (F)	Analysis of Variance: Probability	St. Deviation for Intra-Individual Variation
	TOTAL NONTHERAPY GROUP						
Periods II, III, and IV	54	13.03					
Among Person Means			53	1.4024	3.00	<.01	
Within Persons			108	.4674			.684
Periods V, VI, and VII	33	13.10					
Among Person Means			32	.4472	1.67	.01-.05	
Within Persons			66	.2670			.517
Periods II-VII	26	13.15					
Among Person Means			25	1.1823	2.68	<.01	
Within Persons			130	.4411			.664
	INITIAL HEMOGLOBIN VALUE 13.5 GMS. OR MORE						
Periods II, III, and IV	20	13.36					
Among Person Means			19	1.2686	1.88	.05	
Within Persons			40	.6740			.821
Periods V, VI, and VII	9	13.26					
Among Person Means			8	.2232			
Within Persons			18	.3322	*		.576
	INITIAL HEMOGLOBIN VALUE 12.5-13.4 GMS.						
Periods II, III, and IV	18	13.12					
Among Person Means			17	.9040	2.40	.01-.05	
Within Persons			36	.3767			.614
Periods V, VI, and VII	14	13.24					
Among Person Means			13	.3054	1.11	>.05	
Within Persons			28	.2760			.525
	INITIAL HEMOGLOBIN VALUE LESS THAN 12.5 GMS.						
Periods II, III, and IV	16	12.50					
Among Person Means			15	.9600	3.08	<.01	
Within Persons			32	.3113			.558
Periods V, VI, and VII	10	12.76					
Among Person Means			9	.4107	2.10	>.05	
Within Persons			20	.1957			.442

*Within persons variation greater than variance for individual means.

of this periodic or intra-individual variation is presented in Table 7. The standard deviation for intra-individual variation is shown for the total nontherapy group and for each of the three subgroups. Since there was a marked decrease in the number of persons in the Study after the fourth examination, intra-individual variation is shown separately for the first three reexaminations which have an interval of about nine months with one examination at approximately the middle of the interval and for the last three reexaminations which have an interval of one year with a mid-year examination. For the total nontherapy group, individual periodic variation for all six reexaminations having a total interval of twenty-eight months also is shown.

The standard deviation for intra-individual variation for the entire nontherapy group at the second, third, and fourth examinations is .684 gm. and at the fifth, sixth, and seventh examination it is .517 gm. The standard deviation for the earlier series of examinations is significantly greater than for the later series. This may have been the result of greater error variation[8] in the earlier series of determinations or there may have been less individual variation in the last year of the Study.

When the intra-individual variation for the three subgroups according to a previous examination value is compared for the earlier and later series of examinations, a higher standard deviation is found for each subgroup in the earlier series but the difference is significant only for the group with initially high hemo-

[8] Differences between any two or more hemoglobin determinations are a composite of error variation and true physiological change in the hemoglobin level. If the former is known, the latter can be measured. The accidental error of determinations usually is based on a series of two or more determinations on independent blood samples taken in close succession. For independent duplicate determinations by the same technician, the standard deviation for error variation in these data was found to be .174 gm. (1) However, this is not a satisfactory measure of the total procedural or error variation, for, as previously discussed, additional variation believed to be procedural affected the values obtained at different periods. The adjustment of periodic values partially eliminated procedural periodic variation but, since this was not an absolutely constant factor, the residual variation, which is of unknown magnitude, would make the total error variation included in the intra-individual variation greater than the .174 gm. found in duplicates.

globin values. This latter group also shows significantly greater intra-individual variation for the second to fourth examinations than either of the lower hemoglobin groups. It seems probable, though not definitely proved, that individuals selected on the basis of a relatively high hemoglobin value did have greater intra-individual variation than those with medium or low hemoglobin values. This is consistent with the earlier finding that, on the average, the high hemoglobin group gradually lost its superiority over the intermediate group but the low hemoglobin group continued to be relatively low. In other words, unusually high hemoglobin values were, for the most part, temporary and those who had them showed wide periodic fluctuations.

Within each subgroup of the nontherapy subject, individuals differed significantly with respect to their mean hemoglobin levels for the second, third, and fourth examinations. In spite of high intra-individual variation for these examinations, average individual levels were different and none of the subgroups were really homogeneous. At the last three examinations, the groups became homogeneous, that is, individual means for the three examinations did not differ more than would be expected from their intra-individual variation. For the total nontherapy group, individuals continued to differ significantly for the later series of examinations but this is due entirely to the low hemoglobin group. If the middle and high groups are combined, individual means are not significantly different and these form a homogeneous group. Thus, two years after the initial examination, individuals with intermediate or high values originally were no longer characterized by different hemoglobin levels although they maintained individual differences for a year or more.

Other Studies of Intra-Individual Variation

Studies of individual variation over various time intervals have been made and it is of interest to compare the periodic variation

at approximately six-month intervals obtained in this Study with individual variation at shorter intervals.

Studies of diurnal variation have been reported by Rabinovitch (2) and McCarthy and Van Slyke (3). Rabinovitch made hemoglobin determinations on twenty men six times during the day, at two-hour intervals from 8 A.M. to 6 P.M., using the oxygen combining capacity method of Van Slyke. The mean standard deviation for intra-individual variation during the day is 5.2 per cent (computed by us). The 100 per cent value for hemoglobin is not reported, but 5.2 per cent is 0.7 to 0.8 gm. McCarthy and Van Slyke made six observations on hemoglobin at three-hour intervals from 9 A.M. to 11 P.M. using the carbon monoxide capacity method. An analysis of their data has been published by Mole (4) who reported that the standard deviation for the six daily values on twelve men was 0.54 volume per cent or 0.40 gm. of hemoglobin. Both studies indicate that diurnal variation may be very large. The daily variation found by Rabinovitch is as great as the highest periodic variation found for any group in our Study; that found by McCarthy and Van Slyke is similar to the minimum periodic variation shown for any group in our Study. On the other hand, apparently under some conditions variation within one day may be small; a standard deviation of 0.19 gm. is probably little larger than the blood sampling and accidental procedural error of the determinations.

Differences in hemoglobin estimates for college women made at intervals ranging from one week to six months have been reported by Donelson, Leichsenring, and Ohlson (5). All determinations were made on morning blood samples. The reported standard deviation for differences in hemoglobin values at one-week intervals is 0.79 gm., at two to six weeks is 0.87 gm., and at seven weeks to six months is 1.20 gm. For comparison with the standard deviations for periodic intra-individual variation shown in Table 7, these standard deviations should be divided by

$\sqrt{2}$ to obtain the standard deviation for variation from the mean of the two estimates used in obtaining differences. On this basis, the standard deviations for variation are: 0.56 gm. at weekly intervals, 0.62 at two to six weeks, and 0.85 at seven weeks to six months; and, as the groups examined were large (238, 137, and 92, respectively), these standard deviations are significantly different.

At one-week intervals the individual variation for these women is greater[9] than that for diurnal variation found by McCarthy and Van Slyke (3). It is about equal to the individual periodic variation (S.D., 0.52 gm.) found in our Study for three examinations at six-month intervals in the third year of the Study, but somewhat lower than the periodic variation (S.D., 0.68 gm.) found for three examinations in the earlier years of the Study. In the study of college women by Donelson, *et al.,* intra-individual variation for intervals of two to six weeks gave a standard deviation of 0.62 gm. and this is similar to the standard deviation of 0.66 gm. obtained in our Study for six observations over a total period of 28 months, and for the longer intervals of seven weeks to six months the standard deviation of 0.85 gm. is significantly higher than the periodic variation found in our Study.

Donelson, *et al.* also report that day-to-day determinations on four women for periods of 27, 28, 39, and 39 days had the following standard deviations: 0.81 gm., 0.54 gm., 0.69 gm., and 0.71 gm. The average standard deviation is 0.7 gm. Over a period of three months, Reich and Green (6) made hemoglobin determinations every three or four days for six young women, obtaining 28 values for each woman. The determinations were made on peripheral blood with a Sahli instrument; all are reported and

[9] Hemoglobin determinations were made on duplicate samples of finger-tip blood by the Newcomber method in the study of Donelson, Leichsenring, and Ohlson. This method has greater error variation than the CO capacity method used by McCarthy and Van Slyke and also has greater error variation than the photoelectric method of Evelyn used in the present Study. Therefore, some of the differences in intra-individual variation may be due to greater error variation.

are given in per cent of hemoglobin. The standard deviations for intra-individual variation over the three months have been computed and converted to grams using 14.0 gms. as 100 per cent, although the 100 per cent value was not reported. For these six women the standard deviations are: 0.70, 0.57, 0.69, 0.73, 0.70, and 0.64 gm., and the average standard deviation is 0.7 gm. Reich and Green were studying the effect of menstruation on hemoglobin values, but found no evidence of variation associated with the menstrual cycle. Thus, the day-to-day variation for about one month and the variation for three to four-day intervals over three months in these two studies are the same, and are as large or larger than the periodic variation shown for our subjects studied over a three-year period.

It is clearly evident that hemoglobin content of the blood is not stable. There is about one chance in three that two values obtained within one day will differ as much as 0.6 gm. or more, and one chance in twenty that the difference will be greater than 1.1 gms. on the basis of the McCarthy and Van Slyke (3) findings. From day to day and at longer intervals, equal or greater differences are to be expected. Therefore, in order to obtain an average hemoglobin level that is typical or representative for an individual, several values should be obtained, preferably on several days at different times of the day. Differences among persons shown by values obtained at a single examination reflect the intra-individual variability of the hemoglobin level and in large part are of no significance.

Summary and Discussion

Fourteen white women who had hemoglobin values at an initial examination from 8.2 to 11.9 gms. were given reduced iron or feosol for periods of 12 to 31 months, and reexaminations were made at intervals after therapy as follows: 10-12 weeks, 7 months, 12 months, 19 months, 25 months, and 31 months. At

no examination was there a significant difference between the mean levels for the iron and feosol subjects.

Three colored women who had initial values from 10.0 to 11.9 gms. took reduced iron and one with an initial value of 11.2 gms. took feosol for 31 months. Their average hemoglobin level was consistently below that for the white women, although at the initial examination (six months before therapy was begun) the average hemoglobin level for the colored and white women was approximately equal. However, after 7 months of therapy, the differences between the colored and white were not significant statistically.

The average hemoglobin level for the white women after 10-12 weeks of therapy was 12.6 gms. and it did not increase significantly at any later examination. The average hemoglobin for colored women after three months of therapy was 11.5 gms. and after 7 months was 12.2 gms; thereafter it did not increase significantly.

A "control" group of white women who had hemoglobin values ranging from 11.5 to 12.0 gms. at the initial examination was reexamined at the same intervals as the therapy group. At every examination period the average hemoglobin level for the "control" subjects was similar to that for therapy subjects. At no examination period did the average hemoglobin levels for the "control" and for the therapy subjects attain the average levels obtained for women who had had higher values at the initial examination and received the periodic reexaminations.

Both therapy and all nontherapy subjects showed large individual variations from one period to another. This intra-individual variation, which is found also within one day and from day to day, is so great that determinations at a single examination are unsatisfactory for classifying persons as having low, average, or high values, since any value obtained may be an extreme fluctuation from the representative, average level of the individual

as a result of accidental technical error, temporary physiological variation, or both. It is interesting, however, that in spite of this individual variation, and the fact that the therapy subjects and "control" subjects were selected on a single determination, both *groups* were characterized throughout the three years by relatively low hemoglobin values. Undoubtedly, there were some women included in each group whose usual or average levels at the beginning of the Study were really considerably higher than their initial values. These individuals cannot be identified and differentiated from those whose average levels initially were subnormal on the basis of the single initial determination.

Although the therapy subjects as a group failed to obtain higher levels than the "control" subjects, subjects in both groups exhibited several patterns of apparent change. But because of the considerable diurnal, and day-to-day variability, it is impossible to categorize them as real changes, on the basis of a few widely spaced examinations. Some exhibited an apparent increase only to be followed by a decline. Two in the therapy group with relatively low initial values showed a slow, steady advance; one of them declined at the last two examinations. The subject with the lowest initial value showed a sharp increase after three months of therapy to a moderate level and thereafter made no further gain. Among subjects with mild degrees of hypochromic anemia who had received iron therapy for sixty days, or continuously during the study to a maximum of twenty-six weeks; Fowler and Barer (7) found that, following a rise in hemoglobin levels for about ten weeks, the majority tended to return to the pretreatment level; others continued to have values somewhat above it. They suggested that the former group actually had only low normal values. This same interpretation could be applied to our therapy subjects whose average level for two and a half years remained below the normal average. Indeed, the over-all failure of the subjects receiving therapy to surpass in hemoglobin level those not

receiving it might also be attributed to the same reason; namely, that all of the subjects in the Study had only low normal hemoglobin values. Such a view connotes that the subject by his very nature possesses low values that cannot nor need not be elevated. Actually, this discrimination between two identically low values, calling the one normal and the other abnormal, is based upon the therapeutic test. Yet it is scarcely permissible to designate low values as normal because they fail to respond to iron; for it does not cover influences that might be preventing an increase, nor does it exhaust all possible therapeutic measures. Hence, designating the subjects as low normal is not the only interpretation.

At least two other possible explanations should be considered in relation to the failure of the group receiving iron to attain higher hemoglobin levels than the nontherapy group. The one is the influence of nondietary conditions in the etiology of deficiency states. According to Heath (8), strong evidence indicates that a diet deficient in iron will not produce iron deficiency unless various stresses upon the body are likewise attendant. Gray and Wintrobe (9) state that chronic hypochromic anemia in women is the resultant of three influences: either faulty alimentary function or defective diet, or both; and excessive requirements for hemoglobin induced by such conditions as pregnancy, menstruation, and menorrhagia. Relapse is common in this type of anemia if increased requirements for hemoglobin persist; but it may often be prevented if the condition necessitating excessive requirements is removed or controlled. On the other hand, infection may retard response to therapy in hypochromic anemia (9, 10, 11). This mechanism should not be overlooked in a therapeutic failure or an incomplete response.

The second possible explanation for the failure of the group receiving iron to gain higher hemoglobin values than the "control" group embodies the evidence that multiple nutrients are necessary for the production of hemoglobin and maintenance of

a maximum level. Obviously iron is one, as reports of therapeutic response attest (7, 9, 12, 17). In 1934 Whipple and coworkers (13) studying anemia induced in dogs by blood withdrawal differentiated between iron and the organic factors in hemoglobin regeneration. Again, these investigators (14), pointing out the dissociation between the potency for hemoglobin production and the iron content of different fractions of liver, reaffirmed the view that not one but several nutrient factors have a potent influence on the regeneration of hemoglobin. Later, Whipple (15) enumerated several nutrient factors conducive to hemoglobin production, among them certain amino acids. Prompt elevation of a low hemoglobin level in a child by administration of amino acids has been reported (16). Obviously, a low hemoglobin level due mostly to protein deficiency, for example, and to a less extent to iron deficiency, would respond only moderately and incompletely to iron alone. Thus, failure to respond either fully or at all to iron could be due to nondietary conditions or a deficiency in hemoglobin-producing nutrients other than iron, or both.

Acknowledgments are made to Mead, Johnson and Company for the reduced iron supplied for the Study.

References

1. Wiehl, Dorothy G.: Accuracy of Hemoglobin Determinations on Finger-Tip Blood. Milbank Memorial Fund *Quarterly*, January, 1946, xxiv, 1, pp. 1-28.

2. Rabinovitch, I. M.: Variations of the Percentage of Hemoglobin in Man During the Day. *Journal of Laboratory and Clinical Medicine*, 1923-24, 9, pp. 120-123.

3. McCarthy, Earl F. and Van Slyke, Donald D.: Diurnal Variations of Hemoglobin in the Blood of Normal Men. *Journal of Biological Chemistry*, May, 1939, 128 pp., 567-572.

4. Mole, R. H.: Diurnal and Sampling Variations in the Determination of Haemoglobin. *Journal of Physiology*, June, 1945, 104, 1, pp. 1-5, London.

5. Donelson, Eva G.; Leichsenring, Jane M.; and Ohlson, Margaret A.: Variability of Certain Factors in the Blood Picture of Women. *American Journal of Physiology*, March, 1943, 138, 4, pp. 626-629.

6. Reich, Carl and Green, Dorothy: Red Cell Regeneration During the Menstrual Cycle. *Archives of Internal Medicine*, March, 1932, 49, pp. 534-538.

7. Fowler, W. M. and Barer, A. P.: Some Effects of Iron on Hemoglobin Formation. *American Journal of Medical Science*, 1941, 201, pp. 642-651.

8. Heath, E. W.: Iron in Nutrition. Chapter vii—Handbook of Nutrition. Chicago, 1943, American Medical Association.

9. Gray, L. A. and Wintrobe, M. M.: Chronic Hypochromic Anaemia in Woman. A Consideration of its Etiology and Treatment, With Special Reference to the Relationship of Gynecologic Disorders. *American Journal of Obstetrics and Gynecology,* 1936, 31, pp. 3-13.

10. Robscheit-Robbins, F. S. and Whipple, G. H.: Infection and Intoxication. Their Influence upon Hemoglobin Production in Experimental Anemia. *Journal of Experimental Medicine,* 1936, 63, pp. 767-787.

11. Cartwright, G. E.; Lauritsen, M. A.; Humphreys, S.; Jones, P. J.; Merrill, I. M.; and Wintrobe, M. M.: The Anemia Associated with Chronic Infection. *Science,* January 18, 1946, 103, 2664, pp. 72-73.

12. Abbott, O. D. and Ahmann, C. F.: Iron Deficiency Anemia in Children. *American Journal Diseases of Children,* October, 1939, 58, pp. 811-816.

13. Whipple, G. H. and Robscheit-Robbins, F. S.: Hemoglobin Production Factors in the Anemic Horse Liver. *American Journal of Physiology,* 1934, 108, pp. 270-278.

14. Robscheit-Robbins, F. S.; Walden, G. B.; and Whipple, G. H.: Blood Regeneration in Severe Anemia. Fractions of Kidney, Spleen and Heart Compared with Standard Liver Fractions. *American Journal of Physiology,* 1935, 113, pp. 467-475.

15. Whipple, G. H.: Protein Production and Exchange in the Body Including Hemoglobin, Plasma Protein, and Cell Protein. *American Journal of Medical Science,* 1938, 196, pp. 609-621.

16. Bass, M. H.: Deficiency Anemia in Infants. Report of two Cases with Associated Temporary Deficiency of Anti-Anemic Factor in one and Allergy and Abnormal Digestion of Protein in the Other. *American Journal Diseases of Children,* May, 1944, 67, pp. 341-347.

17. Widdowson, E. M. and McCance, R. A.: Iron in Human Nutrition. *Journal of Hygiene,* London, February, 1936, 36, 1, pp. 13-23.

THE MIGRATION OF NATIVE LABORERS IN SOUTH AFRICA[1]

Wilbert E. Moore

IN the development of European colonial administration and economic exploitation of the African continent, the problem of making productive use of native labor has been continuously paramount. Indeed, the labor resources of the continent figured in the world economy long before the completion of political subjugation and regular colonial administration. The slave trade provided one kind of answer to the problem of using native labor, representing in a sense the removal for processing elsewhere of a replaceable natural resource. With the development of tropical agriculture, mining, and permanent white colonization, the problem became one of using tribal natives for local economic production. Although slavery, called by one name or another, has been practiced at one time or another in all parts of the continent, there has gradually been established an indirect, less openly coercive expedient for the integration of culturally and economically backward peoples into modern economic life. This coercion by indirection, which is more in keeping with European canons of law and ethics and conceptions of productive relationships, has been accomplished mainly by the use of the power of taxation as a prerogative of constituted governmental authority. Tribal natives have been brought within a wage and money economy by levying head taxes or hut taxes, payable only in cash, and thus obtainable only by wage employment or by selling agricultural produce. The taxation policy has been supplemented in South and East Africa by the seizure of good agricultural land by Europeans and the confinement of tribal natives to ever narrowing territories or preserves.

[1] From the Office of Population Research, Princeton University. This paper was presented at the annual meeting of the Population Association of America at Princeton, New Jersey, May 31, 1946.

Aside from a whole range of questions concerning the difficult adaptations of native institutions to European culture and civilization as represented in piecemeal contacts,[2] the full utilization of native labor resources has been blocked by inconsistencies in the policies of Europeans. Throughout British South Africa (as well as in most of East Africa, namely, where there is a strong white settlement) a racial caste system prevails. This inevitably affects the division of labor, and its particular form in South Africa affects also the actual territorial disposition and mobility of labor. Not only are some jobs regarded as exclusively African occupations and others as exclusively European, but also some territories are regarded as appropriate permanent residences of natives and others as exclusively under the ownership and control, if not the exclusive occupancy, of Europeans.

This dual separation between Europeans and natives—of strata in the social scale and of areas within the country—has its inconsistencies. The territorial segregation assumes completely separate communities; this is in exact opposition to the demand for cheap and exploitable native labor in the white community. To some extent this inconsistency is resolved by the use of more or less temporary laborers who retain tribal affiliations and are considered as residents of the native reserves. This in turn creates a number of serious difficulties, not only for the white employer but also for the economy and social structure of the native villages. On the other hand, the caste system of occupational distinction would bar full qualitative use of native labor, even if the labor force were less transitory and mobile.

It is only against this background of dual separation that the particular features of migratory native labor in South Africa can be understood.

[2] *See,* for example, Hunter, Monica: REACTION TO CONQUEST: EFFECTS OF CONTACT WITH EUROPEANS ON THE PONDO OF SOUTH AFRICA. London, Humphrey Milford, Oxford University Press, 1936; Malinowski, Bronislaw: THE DYNAMICS OF CULTURAL CHANGE: AN INQUIRY INTO RACE RELATIONS IN AFRICA. New Haven, Yale University Press, 1945.

Migratory Labor and Native Employment

In British South Africa there are four main types of demand for native labor in the white community: agriculture, mining, manufacturing, and domestic service. Table 1 indicates the relative importance of these modes of economic activity among natives in the Union of South Africa, but unfortunately does not distinguish within the category of "agriculture" between tribal natives and those employed by European farmers or "squatting" on land legally owned by white cultivators. In any event, European agricultural production does not depend heavily upon migratory farm labor but rather enjoys a more or less permanent native labor force in various degrees of personal dependency upon the white land owner.[3] Similarly, migratory labor is rarely recruited in the native territories specifically for domestic service, which rather depends upon fairly permanent resident natives, whether in urban or rural areas. Manufacturing depends to a considerable extent upon unskilled native labor recruited on a temporary basis, but, because of the typically small size of estab-

Table 1. Economic activity of native males and females, 1936.[1]

Economic Group	Males		Females	
	Number	Per Cent	Number	Per Cent
Agriculture	1,437,087	62.4	1,659,349	86.5
Mining	393,020	17.1	—	—
Manufacturing	210,407	9.1	3,358	0.2
Transport and Communication	90,193	3.9	146	—[a]
Commerce and Finance	6,447	0.3	242	—[a]
Professions, Sport, Entertainment	17,605	0.8	4,335	0.2
Personal Services	112,901	4.9	243,369	12.7
Other	35,411	1.5	8,520	0.4
Totals	2,303,071	100.0	1,919,319	100.0

[a] Less than one-tenth of one per cent.
[1] Union of South Africa, Sixth Census, 1936, Vol. IX, pp. 71, 74.

[3] *See* Tinley, J. M.: The Native Labor Problem of South Africa. Chapel Hill. University of North Carolina Press, 1942, pages 85-98.

lishments and their territorial dispersion, is less exclusively dependent on nonresident labor than is mining with its predominant concentration in the Witwatersrand area of Transvaal Province. The gold mines of the Rand provide the most important single source of employment for migratory workers within the Union, with much smaller numbers employed in diamond mines and manufacturing establishments. Copper and tin mines have an analogous significance in the economic structure of the Rhodesias. Thus the most outstanding economic feature of native labor migration is the recruitment of laborers in the native reserves under contract or indenture for work in the fairly limited mining areas.

This clear territorial concentration of economic activity employing large numbers of native workers would seem to facilitate the statistical analysis of labor mobility. And in fact the movement of labor to the mining areas is sufficiently marked to make its main features clear. However, numerous difficulties impede precise statement of the situation.

As previously noted, European employers for the most part do not recruit a *permanent* labor force for work in the mines, nor can they rely upon a resident urban proletariat attracted and held by employment opportunities. However much individual employers might find a dependable, resident labor force advantageous, they are barred from fostering such a development by the principle of territorial segregation and the attempt to maintain natives in tribal conditions. This policy is naturally reinforced by the limited, although increasing, interest of tribal natives in modern economic life and their preference for traditional modes of agricultural life functionally related to the whole institutional framework. Concretely, this means that the native labor force as enumerated, for example, by any given census may be quite different from that which would have been enumerated a few months earlier or later. The infrequent censuses of the Union do not at-

tempt to classify natives according to permanent residence; they are enumerated *de facto* and not *de jure*. Thus, although natives in 1936 were tabulated according to place of birth, there is no way of determining how many of the migrants at the time of the census were temporarily at employment centers and how many were more or less permanent additions to the labor force (the so-called "detribalized natives"). The direction of the flow can be determined, but not its exact size for a given period or its duration with respect to individual components.

Workers for the principal centers employing native laborers are recruited both from the predominantly native areas within the Union and from neighboring territories .The data concerning native immigration[4] from the three High Commission Territories — Basutoland, Swaziland, and Bechuanaland — from Mozambique, or from British colonies to the north are no more satisfactory than those relating to migration within the Union. Statistics of immigration for the Union exclude natives. The number of natives leaving the High Commission Territories during any year may be approximately determined from passes issued in those territories; how many return in the course of the year is completely unknown. For Basutoland the 1936 and earlier censuses enumerated "absentees," but the difficulty of length of residence remains. Even less evidence exists with respect to other areas of labor recruitment, except that the annual number of workers under indenture from Mozambique is fixed in round numbers by treaty. These scattered bits of evidence, supplemented by statistics on place of birth and by statistics of employment, provide only rough measures of the ebb and flow of migratory movements.

In general, therefore, the possible statistical description of native labor migration in British South Africa is considerably less

[4] "Native" as used in this discussion refers uniformly to Negroid natives of the African continent, primarily Bantu in the areas here under consideration. This explains the use of such otherwise contradictory terms as "native immigrants."

than could be desired. Data on place of birth, for example, do not have the same significance as similar data where migration involves a definite change of legal residence, and where census data present *de jure* as well as *de facto* enumerations. On the other hand, the significance of temporary migration with more or less frequent turnover of labor supply should not be misinterpreted. As long as the total labor force remains reasonably constant, or is at most subject only to long- term variations, the enumerated native population may for some purposes be regarded as permanently resident in the places where enumerated. This would be true even if no laborer gained legal residence at his place of work and remained only for one year under indenture and never returned. If each departing worker is replaced by another during the same year, or any shorter or longer period under consideration, the total for the period obviously remains constant.

The foregoing should not obscure other demographic, as well as economic and social, consequences of such labor mobility. The "permanent" labor force by statistical artifact would still not be self-reproducing by natural increase. Moreover, extended periods of absence on the part of the laborers from their truly permanent places of residence may affect the demographic balance in those areas. Unfortunately the available data do not allow adequate appraisal of these effects. They permit, indeed, only the determination of the direction of labor mobility, its approximate extent in terms of statistics on place of birth and on employment in labor centers, and some of the more obvious changes in population composition resulting from the movement.

Internal Migration

The census enumeration of natives by place of birth allows the tracing of migratory movements only among the four provinces of the Union and not by smaller administrative districts. Indirect evidence, however, in the form of age and sex distribu-

Province of Birth	Net Balance in Province of Enumeration			
	Cape	Natal	Orange Free State	Transvaal
Cape	——	+18,089	+18,478	+233,846
Natal	−18,089	——	+1,414	+73,634
Orange Free State	−18,478	− 1,414	——	+70,710
Transvaal	−233,846	−73,634	−70,710	——

[1]Based upon data in Union of South Africa, Sixth Census, 1936, Vol. IX, p. 70.

Table 2. Place of enumeration against place of birth as an index of internal migration of natives among the four provinces of the Union of South Africa, Census of 1936.[1]

tions allows a more definite identification of the two principal sources within the Union of native laborers recruited for work in the Transvaal, namely, the Transkeian district of Cape Province and the Zululand district of Natal. The data on place of birth in the 1936 census allow calculation of the net balance of movement among the provinces as represented by the enumerated native population in 1936 (Table 2). Aside from a quite minor movement from Natal to Orange Free State, these data show the Cape Province to be something of a "universal donor," and the Transvaal to be a "universal receiver." As might be expected from knowledge of the South African economy, the most significant movement is that from all of the other provinces to the Transvaal. The predominant importance of that movement

Table 3. Place of enumeration against place of birth as an index of internal migration of urban male natives among the four provinces of the Union of South Africa, Census of 1936.[1]

Province of Birth	Net Balance in Province of Enumeration			
	Cape	Natal	Orange Free State	Transvaal
Cape	——	+4,176	+1,403	+165,223
Natal	−4,176	——	−34	+44,853
Orange Free State	−1,403	+34	——	+19,382
Transvaal	−165,223	−44,853	−19,382	——

[1]Based upon data in Union of South Africa, Sixth Census, 1936, Vol. IX, p. 70.

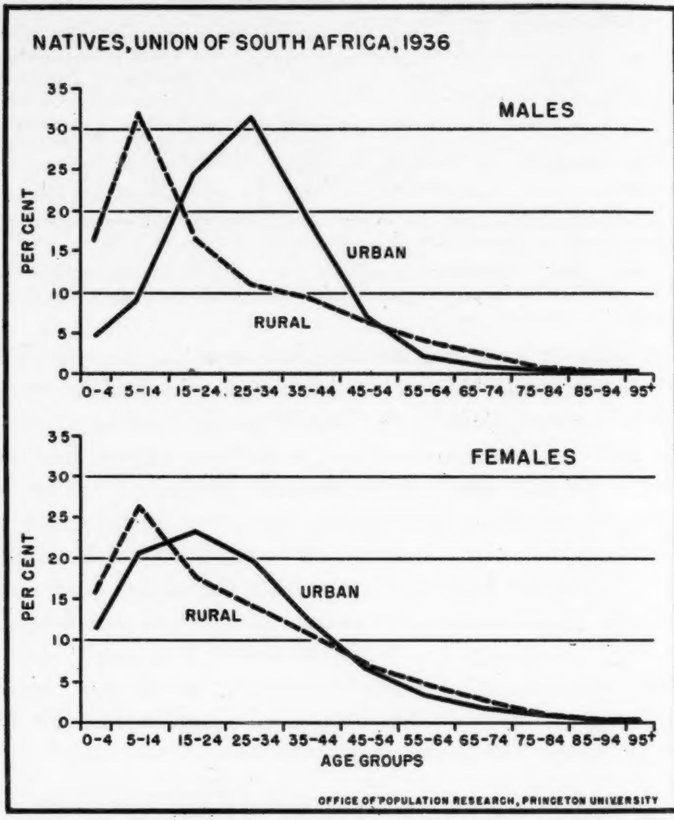

Fig. 1. Age distribution of native males and females in rural and urban areas of the Union of South Africa, 1936. From Union of South Africa: Sixth Census, 1936, Vol. IX, page xi.

is made even clearer if the calculation is limited to native males enumerated in urban areas. Table 3 indicates that on this basis other inter-provincial movements are substantially reduced or even reversed, whereas the volume of native male migration from all provinces to the urban areas of the Transvaal represents virtually half of the total migration to the province.

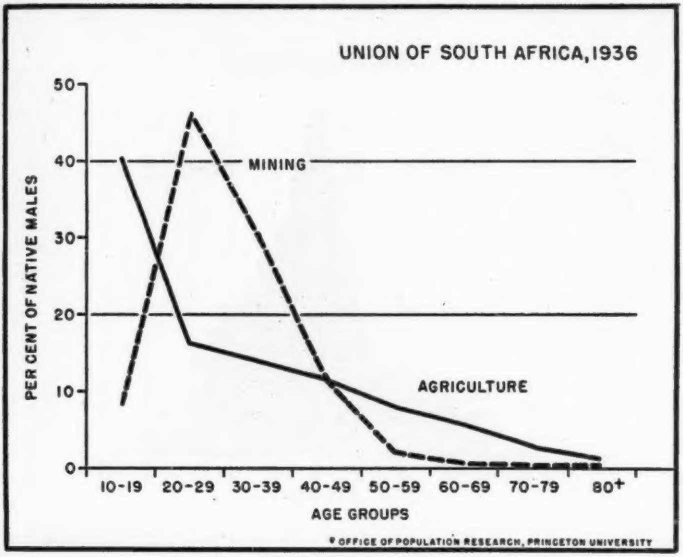

Fig. 2. Age distribution of native males engaged in agriculture and mining, Union of South Africa, 1936. From Union of South Africa: SIXTH CENSUS, 1936, Vol. IX, page XVI.

Three points will bear reiteration for their relevance to the interpretation of these balances in migratory movements: (1) There is no satisfactory way of separating permanent migration of detribalized natives to places of employment in predominantly white areas from the temporary migration of tribal natives to labor centers. (2) The reliability of the size of these balances is relative to the numerical stability of native employment.[5] (3) The particular composition of the enumerated native population is unstable in the degree that there is a continual ebb and flow of migrants.

[5] Independent evidence on native employment in the chief labor centers indicates some seasonal variation, with a low point around the end of December and a high point in June or July. These variations are by no means uniform from one year to the next, however, and are partly affected by longer-term trends in employment. In general, May, the month of the 1936 census, seems fairly representative, at least for that year. *See:* Union of South Africa, *Monthly Bulletin of Union Statistics*, issues for 1936 and other years.

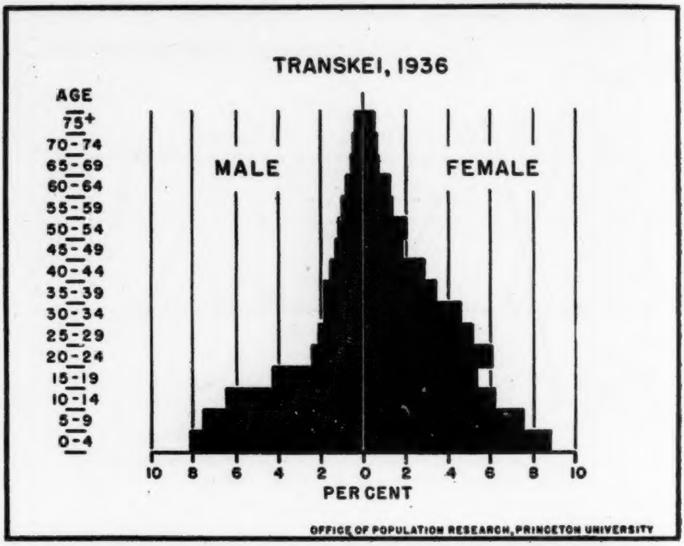

Fig. 3. Age and sex distribution of natives in Transkei, Cape Province, Union of South Africa, 1936. From Union of South Africa: SIXTH CENSUS, 1936, *Ages and Marital Condition of the Bantu Population,* Table 3, pages 6-27.

The effects of these migratory movements, however temporary the stay of particular migrants, is reflected in the age and sex composition of the native populations in the areas of supply and in the areas of labor demand. The percentage age distribution of rural and urban native males (Figure 1) indicates that one aspect of the migratory movement is a concentration of native males of working ages in urban areas. The selective aspect of the migration with respect to sex is emphasized by comparison of rural and urban age distributions of native females (Figure 1) which shows no such marked contrast as found with native males. Another aspect of the movement is a shift out of agriculture into other economic activities, particularly mining. The results of this movement may be seen in the contrasting age distributions of native males in agriculture and in mining (Figure 2).

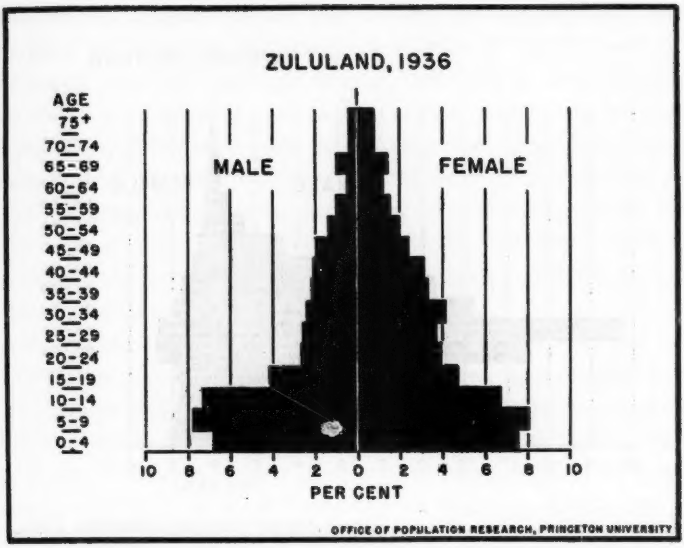

Fig. 4. Age and sex distribution of natives in Zululand, Natal Province, Union of South Africa, 1936. From Union of South Africa: Sixth Census, 1936, *Ages and Marital Condition of the Bantu Population,* Table 3, pages 6-27.

As previously indicated, the data on place of birth of the native population of the Union of South Africa as enumerated in 1936 allow only the determination of net balances of movement among the four provinces. However, a closer identification of the areas of origin and of destination may be gained from the age-sex composition of the native population by smaller areas. Figures 3, 4, and 5 show the per cent of total native population represented by each quinquennial age-sex group in the Transkeian area of Cape Province, Zululand in Natal, and the Witwatersrand urban concentration in Transvaal. The Transkeian and Zululand areas are the two portions of the Union of South Africa with almost entirely native populations, and these constitute the principal areas of origin within the Union of the heavy concentration of males of working ages evident in the Witwatersrand gold

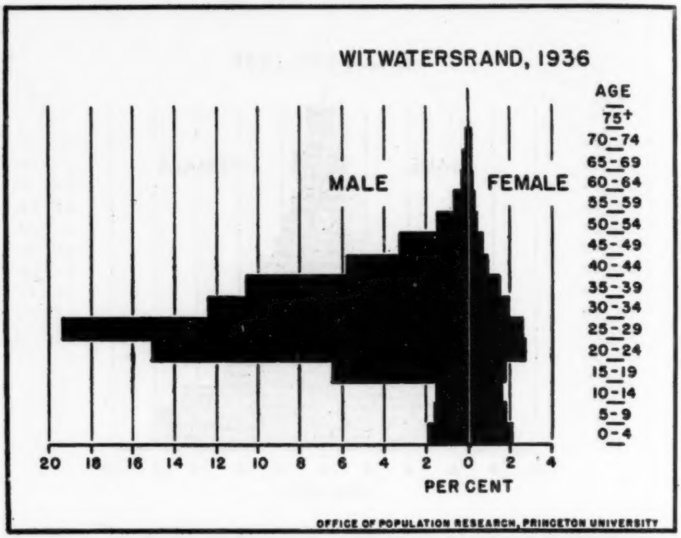

Fig. 5. Age and sex distribution of natives in the Witwatersrand, Transvaal Province, Union of South Africa, 1936. From Union of South Africa: SIXTH CENSUS, 1936, Vol. IX, Table 5, page 27.

mining area. It should be observed that this is a rough and indirect measure of the size and direction of migratory flow, as the native laborers found in the Witwatersrand are also drawn in lesser numbers from other parts of the Union and in substantial numbers from outside the country, as will be noted below.

MIGRATION FROM OUTSIDE THE UNION

The pull of the labor markets of the Union of South Africa extends beyond the political boundaries of the state. It is essential to an understanding of substantial flow of native migratory workers from surrounding areas to bear in mind certain peculiar features of South African economy. The social structure includes a somewhat unstable combination of three elements of particular importance in this connection. Those elements are (1) white

supremacy, enforced in law and custom and applied in a caste division of labor; (2) territorial segregation of natives; and (3) economic activity, especially mining, that rests in large measure on cheap gang labor by natives. *This is an economic regime based upon cheap labor used with deliberate waste:* there is the waste arising from the failure to develop and use potential skills of native workers, owing to the institution of white supremacy, and the waste of rapid turnover and expenses of continual recruiting, owing to the refusal to develop a stable resident labor supply in the employment centers.

It is understandable that this combination of structural elements may produce recurring or chronic shortages of labor supply, somewhat independent of the number of native nationals of working ages. This in fact has been the situation in the Union of South Africa and it has given rise to the recruiting of native workers in other parts of British South and East Africa, and in the Portuguese colony of Mozambique.

At the time of the 1936 census there were in the Union about one-third of a million natives born outside the country (Table 4). This represented 5 per cent of the total native population. Almost half of the immigrants were born in the High Commission Ter-

Table 4. Natives enumerated in the Union of South Africa, Census of 1936, born outside the Union, by specified countries of birth.[1]

Country of Birth	Total Native Population Born Outside the Union	Native Males, Ages 20 and Over, Born Outside the Union
Basutoland	163,838	93,686
Portuguese East Africa	98,031	87,643
Swaziland	31,092	18,740
Nyasaland	17,657	16,555
Rhodesias	13,871	12,210
Other	9,288	4,568
Totals	333,777	233,420

[1]Union of South Africa, Sixth Census, 1936, Vol. IX, pp. 68-69.

ritory of Basutoland, which is an enclave within the territorial extension of the Union and adjoins a portion of the Transkeian region in Cape Province. Not all of these migrants were of the temporary sort, however, and a precise distinction is not possible. However, in the 1936 enumeration almost 70 per cent of the total native population born outside the Union were males of 20 years of age and over. These 233,420 immigrant native males may be considered as a maximum estimate of migratory native laborers from outside the Union. Basutoland was the country of birth of about 94,000 of these African male immigrants, and about 88,000 were born in Mozambique (Portuguese East Africa). Those two areas alone accounted for approximately 78 per cent of the total native male immigrants of working age.

Although no official statistics record the annual number of na-

Table 5. Total employment and employment of immigrants in native centers, annual average, 1925-1939.[1]

Years	All Mines			Total Employment		
	All Native Employees	Immigrant Native Employees		All Native Employees	Immigrant Native Employees	
		Number	Per Cent		Number	Per Cent
1925	218,071	114,965	52.7	306,092	124,502	40.7
1926	231,325	123,100	53.2	326,281	134,005	41.1
1927	235,175	128,350	54.6	332,491	139,178	41.8
1928	243,276	134,222	55.2	344,419	145,082	42.1
1929	239,310	130,594	54.6	347,254	141,051	40.6
1930	245,727	127,229	51.8	354,940	137,455	38.7
1931	242,907	118,380	48.7	356,663	129,445	36.3
1932	240,605	107,405	44.6	348,875	117,151	33.6
1933	253,002	101,197	40.0	374,063	111,407	29.8
1934	275,392	109,689	39.8	416,372	124,641	29.9
1935	304,711	127,222	41.8	476,775	147,541	30.9
1936	330,829	138,749	41.9	528,633	162,431	30.7
1937	338,188	158,436	46.8	556,982	185,811	33.4
1938	357,861	174,102	48.6	577,191	200,948	34.8
1939	361,024	174,430	48.3	588,601	199,180	33.8

[1]The annual averages are derived from monthly averages as given in Union of South Africa, *Monthly Bulletin of Union Statistics*, Nos. 37-180 (1925-1936) and Vols. XVI-XIX (1937-1940).

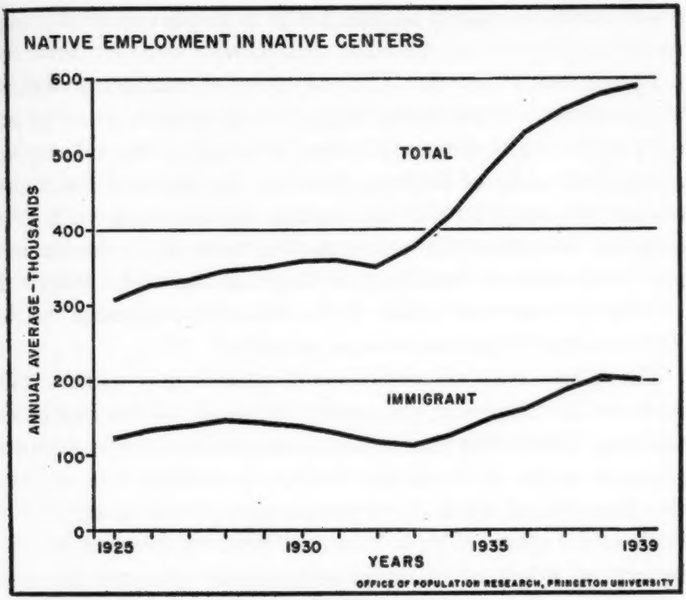

Fig. 6. Total and immigrant native laborers in established labor centers, Union of South Africa, annual averages, 1925-1939. Source: Table 5.

tive immigrants into the Union of South Africa, data are available on native employees, by territory of origin, in the principal labor centers. These labor centers comprise, besides the Witwatersrand gold mines, a number of scattered mining and manufacturing areas,[6] and probably account for nearly all natives employed in the two major types of economic activity that depend upon migratory workers.

From the employment statistics it is possible to arrive at a fairly adequate picture of the annual average number of immigrant laborers during the period 1925-1939. These averages are shown in Table 5 and Figure 6. As shown also in Table 5, immi-

[6] Witwatersrand, Heidelberg, Vereeniging, Rayton, Witbank, Breyten-Ermelo, Dundee and Vryheid, Kimberley, and Orange Free State.

grant workers regularly account for 30 to 40 per cent of the total native employment in the labor centers, with some tendency for the proportion to decrease. The proportion of immigrant workers in the mines is considerably higher, ranging from 40 to 55 per cent, with no such downward trend as is evident in total employment. Both series of averages show an absolute and percentage decline in immigrant workers during 1933 and 1934, with some recovery thereafter. The more marked upswing in the number and proportion of immigrant workers in the mines reflects in considerable measure a shift in the area of recruitment for the Witwatersrand mines, to be noted presently.

The same series of employment statistics also specify, with more or less adequacy, the country of origin of the immigrant workers. These data thus allow a comparison of the principal places of origin of immigrant workers in a longer time perspective than that of the *de facto* enumeration of natives by place of birth in the census of 1936. From the basic employment statistics by area of origin of the employees, annual averages for each country have been computed. Table 6 summarizes these averages

Table 6. Native workers in labor centers by country of origin, 1925-1939 average.[1]

Country of Origin	Employees in All Mines	Total Employees
Union of South Africa	143,301	269,054
Portuguese East Africa	82,655	83,382
Basutoland	33,323	38,218
Bechuanaland	6,411	8,653
Swaziland	5,997	7,030
Rhodesias	1,431	6,024
Nyasaland	1,353	3,084
Total Immigrants	*131,170*	*146,391*
Unclassified	35	264
Totals	274,506	415,709

[1]Based upon data from Union of South Africa, *Monthly Bulletin of Union Statistics*, Nos. 37-180 (1925-1936) and Vols. XVI-XIX (1937-1940). The averages for Bechuanaland, Nyasaland, and the Rhodesias are estimated in part by an apportionment among them of natives from tropical areas, not separately classified by territory of origin.

for the entire period of fifteen years (1925-1939) covered by the available sources. Table 6 shows some considerable differences from the statistics on place of birth in the 1936 census (Table 4). Aside from the fact that the employment statistics represent long-term averages, it is clear that many immigrant natives enumerated in 1936 were not in the category of temporary migrants, at least as represented in the principal labor centers. Thus, for example, the 1936 census shows a larger number of immigrants from the Basutoland enclave than from Portuguese East Africa, whereas migratory workers from the latter territory in the labor centers are more than twice as numerous as those from Basutoland. However, detailed statistics for each year indicate a growing proportion of workers from Basutoland through the 1925-1939 period.[7] It should also be noted that the averages, even those covering a much shorter term than the fifteen-year period summarized in Table 6, refer to those actually in employment in the labor centers and must therefore be presumed to understate the total potential workers in the labor centers at any given time.

Certain features of the migratory movements not appearing in Tables 5 and 6 but evident from the data upon which those tables are based may be noted. The number of native immigrant laborers from Swaziland showed little change throughout the period, in contrast to the fairly sharp fluctuations in the number from Portuguese East Africa and the rapid increase of those migrating from Basutoland. On the other hand the decision taken in 1935 to recruit experimentally from tropical areas to the north resulted in subsequent sharp increases in the number of immigrants from Bechuanaland, the Rhodesias, and, especially,

[7] The number of migratory workers from Portuguese East Africa is fixed in round numbers by treaty, which provides also some greater safeguards, particularly in wage payments, than those enjoyed by workers recruited from British territories. The Mozambique natives are under annual contract, and part of their pay is withheld for payment after their return to their home communities. The maximum period of reemployment is six months. The number of workers as fixed by treaty has varied from 80,000 to 100,000 per year. (*See* Official Year Book of the Union of South Africa, 1940, p. 468.)

Nyasaland. These "Tropicals" were almost exclusively employed in the Witwatersrand mines.

These data leave quite unanswered the question of the total number of immigrant laborers entering the Union during any year, as they represent only average numbers of employees. In other words, they reveal nothing concerning the amount of turnover required to keep the given average numbers of workers in employment. The evidence on this matter is scattered and inconclusive. Recruitment figures published by the Transvaal Chamber of Mines, when compared with data on average employment, indicate an approximate turnover of 100 per cent per year during 1925-1932, with a range from 88 per cent to 113 per cent and no marked trend.[8] Subsequent and less complete figures for 1936 and 1937, together with estimates from the same source of average length of individual employment, suggest a somewhat reduced turnover and a smaller increment of new workers.[9]

A comparison of the number of passes issued to natives in Bechuanaland, Basutoland, and Swaziland to proceed to the Union for employment, with the average number from those areas actually employed in established labor centers suggests annual turnover ratios substantially less than 100 per cent for Basutoland and Bechuanaland natives, and considerably over 100 per cent for Swaziland.[10] Because these data come from completely different sources and because there is no assurance that natives uniformly equip themselves with passes to cross generally un-

[8] Transvaal Chamber of Mines: Thirty-Sixth Annual Report, 1925, pp. 142, 155, 164; Thirty-Seventh Annual Report, 1926, pp. 122, 134, 142; Thirty-Eighth Annual Report, 1927, pp. 124, 134, 142; Thirty-Ninth Annual Report, 1928, pp. 142, 155, 161; Fortieth Annual Report, 1929, pp. 184, 193, 200; Forty-First Annual Report, 1930, pp. 116, 125, 133; Forty-Second Annual Report, 1931, pp. 130, 136, 155; Forty-Third Annual Report, 1932, pp. 126, 136, 144.

[9] *Ibid.*, Forty-Fifth Annual Report, 1934, p. 62; Forty-Eighth Annual Report, 1937, p. 21.

[10] Information on number of passes issued each year 1935-1939 is given in Official Year Book of the Union of South Africa, 1940, pp. 1192, 1210, 1234. Employment averages are derived from sources cited in footnote to Table 6.

guarded borders, these ratios cannot be regarded as any more than suggestive.

A reasonably safe and comfortably round guess from this evidence, then, is that the average number of workers employed in the labor centers is an approximate representation of the number of migratory workers entering and leaving the Union each year. How many of these migrants in any year are newly weaned from tribal conditions and how many are former wage earners returning, there is no evidence at all to determine. Because of the unskilled nature of the work performed this is a question of small importance to the individual employer, and of no apparent concern to any other white South African.

Conclusion

The labor system of South Africa presents a nice case of what might be called the relation of migration to social opportunity. If it is the economic development of mining and manufacturing that provides the pull attracting workers from tribal reserves within the Union and immigrants from beyond the national boundaries, it is the network of barriers to social mobility that accounts for an almost equal push back to tribal areas and a constant ebb and flow of unskilled native workers. If this system provides a sort of statistical equilibrium it does not follow that it produces anything like a stable social equilibrium. Native labor migration serves as a bridge between rigid and otherwise incompatible types of social restraint — the caste system and territorial segregation. It makes possible the limited use of native labor while keeping it out of the way. Yet it is probably impossible to bring backward peoples within a money economy without giving them material aspirations that go with that economy. As those aspirations replace the indirect coercion of taxation and territorial restriction, the natives may be expected to protest against their limited opportunities. The restraints thus appear to be subject to pressure that may lead to their collapse.

ANNOTATIONS

WEALTH, WELL-BEING AND POPULATION[1]

AMONG the recent studies that view with some misgiving the slowing growth and imminent decline of Western populations, two works by a leading French demographer must take an important place. In RICHESSE ET POPULATION and BIEN-ETRE ET POPULATION Dr. Alfred Sauvy attempts to integrate once more the fields of economics and demography and to derive from their combination a group of principles and policies that will assist in the adjustment to or prevention of declining numbers. The author is Director of the new French National Institute of Demographic Studies, which is a section of the Ministry of Public Health in the French Government. The author's position indicates that concern over numbers is now a matter of official policy. The studies under review indicate why the author believes the concern to be appropriate, if somewhat tardy.

In WELL-BEING AND POPULATION, the shorter and more informal of the two books, Dr. Sauvy begins by posing the two dangers inherent in the relations of population to productive capacity: underpopulation and overpopulation. As might be expected from that definition of the problem, he subscribes to the view that for given circumstances there is an appropriate or optimum population. This optimum number should be the goal of official policy, both direct and implicit. The author is at pains to point out that policy decisions on a wide variety of matters are made on the assumption of facts about population growth that may be illusory. He shows the extent to which an essentially Malthusian view continues to prevail in countries like France which, in the author's view, are faced with the opposite danger.

[1] Sauvy, Alfred: Richesse et Population. 2e ed. Paris, Payot, Bibliotheque Economique, 1944, 324 pages; Sauvy, Alfred: Bien-Etre et Population. 2e ed. Paris Edition Sociale Francaise, 1945, 229 pages.

Successive chapters of WELL-BEING AND POPULATION provide a sort of primer of population movements and their relation to economic development. The author reviews the "vital revolution" in Europe, with perhaps a slight overestimation of the completeness of the shift to low birth rates in Eastern Europe and especially in Russia. A hasty review of the growing populations of the remainder of the world, and especially of the Orient, completes the perspective in which Dr. Sauvy wishes to place the situation of France. There especially he finds a network of deliberate and unintentional barriers to population growth, representing accumulated economic and political policies that discourage large families while individual choice and knowledge of contraceptive techniques translate the policies into realities.

In WEALTH AND POPULATION the author approaches the definition of population optima in more formal fashion. Here he seeks to relate size and growth of population to level of living and the state of the useful arts. Dr. Sauvy discusses in some detail the relation of the optimum to various states of population growth and age distribution, and to such economic conditions as resources, production, trade, elasticity of demand, and the like. The text is supplemented by numerous graphical and mathematical representations of the alleged relationships. In this discussion Dr. Sauvy seems to have contributed some greater precision to the definition of significant variables without, however, arriving at a truly operational definition of the optimum number for particular combinations of the variables. The reader misses throughout this discussion any reference to English or American literature on the subject.

Differing only in the amount of detail, both books indicate various respects in which a fallacious Malthusianism pervades official and popular opinion on demographic questions. The author indicates how unemployment, housing shortages, concern for population quality, and the "economics of abundance" and its counterpart in economic restrictionism (which the author calls "economic Malthusianism") have been used as conscious or implicit arguments against population growth. With each of these obstacles to growth the author attempts to show either that the argument has no merit or, in some cases, that population growth would actually aid solution of the problems.

Dr. Sauvy's case for increased population is made on exclusively economic grounds; he carefully avoids reference to population as an

element in military power. It may be doubted that the French government's official sponsorship of demographic studies rests so exclusively upon considerations of domestic economic welfare, although that welfare is certainly of some concern in postwar France. The author's position is that in an advanced society with modern technology and with ample resources either under domestic control or obtainable through trade, an expanding population aids rather than hinders the expansion of production and consumption, the adoption of new techniques, and even the improvement of genetic quality. The author is quick to recognize, however, that what is good for the economy as a whole viewed abstractly may be very disadvantageous for most family units viewed concretely. The practical policies with which both books culminate are designed to make the interests of individual families run in the same direction as the interests of the collectivity. Specifically, the author proposes a pronatalist policy encompassing benefit payments and an entire series of graded reductions in the expense of rearing children. This policy he would implement by such economic and fiscal policies as appeared necessary, including reduced restrictions on occupational mobility and on economic production, confiscation of funds used neither for production of goods or for production of children, loans for the newly married with payments acceptable in children, and the like. Some of these policies are now being put into effect in France. It is still too early to estimate their effect and, indeed, unless the fundamental problems of production and trade are solved more satisfactorily than now appears evident, it would be unfair to Dr. Sauvy's program to judge it by the results of incomplete and possibly superficial adherence to it in official policy.

In both books Dr. Sauvy is somewhat more concerned with exposition leading to practical conclusions than with economic demography as such. The author's use of demographic statistics is casual and largely undocumented, reflecting perhaps somewhat different scholarly usages than those customary in the Anglo-American literature. In neither work does the author appear to be concerned with precision of measurement of population movements. The books should rather be read for the able and very literate way in which the author discusses sweeping questions of demographic policy and for the way he answers those questions in regard to the interesting case of France.

WILBERT E. MOORE

ALL THESE PEOPLE: THE NATION'S HUMAN RESOURCES IN THE SOUTH[1]

FOR over two decades the Institute for Research in Social Science at the University of North Carolina has been a beacon of enlightenment on social and economic problems of the South. For this, chief credit goes to Dr. Howard W. Odum who organized the Institute in 1924. From the beginning, Odum's idea was that of directing the major part of the Institute's research toward regional problems of the South in the hope that the multitudinous and complex ills of that region might be better understood and approached intelligently. His success in making the Institute a national center for regional studies has been due not only to his own high qualities of scholarliness and industry but also to his ability to attract brilliant colleagues and to instill in them a fervor for work akin to his own.[2]

One of Odum's outstanding coworkers, Rupert B. Vance, has recently completed ALL THESE PEOPLE: THE NATION'S HUMAN RESOURCES IN THE SOUTH. This is Vance's third major work on problems of the South[3] and it serves to complement Odum's SOUTHERN REGIONS OF THE UNITED STATES. As stated by the author, "This study of the Southern People follows Howard W. Odum's analysis of the resources of society in terms of natural 'wealth', capital 'wealth', technological 'wealth', human 'wealth', and institutional 'wealth'. The idea has been well put by Lancelot T. Hogben in RETREAT FROM REASON, where he points out that the wealth and the welfare of nations depends on (a) the material resources of man's environment, (b) the biological resources of social personnel, and (c) the social resources of organization and institutions for mobilizing the common will to make the fullest use of the first two." (pp. 7-8.)

More specifically, ALL THESE PEOPLE is divided into five parts as follows:

Part I. The Dynamics of Population (pp. 1-153).

[1] Vance, Rupert B.: ALL THESE PEOPLE: THE NATION'S HUMAN RESOURCES IN THE SOUTH. Chapel Hill, The University of North Carolina Press, 1945, 503 pp. $5.00.

[2] For a brief account of the past work of the Institute, *see* Odum, H. W. and Jocher, Katharine (Editors): IN SEARCH OF THE REGIONAL BALANCE OF AMERICA. Chapel Hill, The University of North Carolina Press, 1946, 162 pp. $3.00.

[3] The two preceding ones are:
(a) Vance, Rupert B.: HUMAN FACTORS IN COTTON CULTURE. Chapel Hill, The
(Continued on page 424)

Part II. Population and the Agrarian Economy (pp. 154-247).
Part III. Population and the Industrial Economy (pp. 248-334).
Part IV. Cultural Adequacy of the People (pp. 335-465).
Part V. Social Policy and Regional-National Planning (pp. 466-488).

The South has long had the dubious distinction of being the Nation's outstanding "seed bed" for future population. But for the high fertility of the South the net reproduction rate for the country as a whole would be below replacement requirements. Much of this, of course, is due simply to the fact that the South is more rural than other regions. If this were the *only* factor in the situation there might be small cause for concern. However, the "social problem" elements arise from the coincidence of high fertility and poverty in the rural South. Families tend to be largest in communities where levels of living are lowest, and where facilities for child health and public education are least adequate. Thus, whereas the South contributes a disproportionately large share of the Nation's births, it is correspondingly an area where human resources have been sinfully neglected and wasted. The author sees this situation not only as a challenge to the region but to the Nation as a whole.

The author gives a well-rounded description of the agrarian economy of the South. Like other students of the problem, he holds "that share-tenancy as developed in the Cotton Belt is ruinous of both land and men. . . . The waste of human resources may be made clear by reference to the nutritional problems of the tenant family. The land owner, as indicated, gets his income from staple cash crops. Unless exceptional, he does not devote much of his supervision and financing to seeing that the tenant produces the fruits, meats, milk, and vegetables needed to feed his family. . . . Moreover the tenants, caught in the staple routine and steeped in the need for cash in an economy of book credit, rarely acquires the means, the training, or possibly the inclination, to produce an adequate supply of food or feed crops. . . . Measured by the returns to laborers, croppers, and share tenants, the South's agrarian economy represents the most uneconomic utilization of a large labor force to be found in our country." (pp. 228-229.)

Various changes in the traditional agricultural economy of the South

University of North Carolina Press, 1929, 346 pp.

(b) ——————: Human Geography of the South. Chapel Hill, The University of North Carolina Press, 1932, 596 pp.

are noted. Industrialization is bringing nearby markets for food and dairy products and the A.A.A. program has helped to stimulate diversification. Although the outlook for the mechanical cotton picker is still somewhat uncertain, other forms of mechanization of agriculture have advanced rapidly and have served to dispense with the need for many tenant families. If the mechanical cotton picker proves to be feasible, far-reaching changes in the agricultural economy of the South may be expected.

In Part III, Vance examines the regional distribution of income, industry, and unemployment and attempts to ascertain "what would be involved in a fuller use of material and human resources for the regions and the Nation." As expected, the answer turns out to be more industry for the South. In this section the author also draws upon previously unpublished case studies of two industrial communities in the Southeastern Piedmont, Catawba Valley and High Point, North Carolina.

The cultural adequacy of the South (Part IV) is discussed chiefly in terms of health and education. A series of charts demonstrates that southern states fall into the disadvantaged class with respect to number of physicians and medical-care beds per unit of population, percentage of births attended by physicians, maternal death rates, ratios of stillbirths to live births, infant mortality rates, and per capita expenditures for public health. Parallel situations are found in data on educational attainment, school attendance, and annual expenditures per pupil enrolled in schools. Both public health and formal education are viewed as purchasable commodities. The author reasonably contends that the Nation has a stake in the health and education of the children of the South, for many of these children eventually will migrate to distant cities in search of employment. "Citizens ill-informed and prejudiced become the prey of demogogues and thus tend to break down the equitable functioning of government so necessary for the preservation of the free ballot in a democracy." (p. 445.)

Although the author makes a strong case for equalization of public health and educational opportunity through federal funds, he looks beyond the possibility of federal "hand outs." He urges a regional development that will enable the South to go under its own steam. "More than anything else the future of the Southeast depends upon the development of resources and capacities that are as yet largely unrealized. The region has natural resources and human resources. Their forms of wealth are

primary, but for their development they depend upon the building up of technological resources, institutional resources, and capital resources. The creation of these secondary forms of wealth, as Howard W. Odum has pointed out, are matters of organization, skill, and previous experience. This is both an economic and a cultural task in which the Nation is as vitally concerned as the region itself." (p. 476.)

Space limits prohibit a full and just review of this book. The amount of detailed information it contains is suggested by the inclusion of 146 tables and 281 figures. Many of the figures are base maps of the United States showing how the South compares with other regions with respect to given conditions. A small number of figures, however, might just as well have been omitted since they are rendered illegible by excessive reduction. (*See* Figures 272-274.)

Since the book required seven years for writing and one for publishing, it is not surprising to find some out-dated materials and sentences. Thus in two places (pp. 94 and 146) the author mentions the absence of direct data for the South on fertility differentials by socio-economic class. Before the book was finished, however, National Health Survey materials on birth rates by occupation, income, and education were available for the South and other regions. Furthermore, by the time Vance's book was published, the Bureau of the Census had released a large mass of differential fertility rates by region, education, and rental value of the home, based upon the 1940 Census.

The author has an axe to grind in this book but that axe is concerned with the Nation's human resources in the South.

CLYDE V. KISER

• • •

AGRICULTURE IN AN UNSTABLE ECONOMY[1]

BELIEVING that past studies of agricultural problems like those of industrial problems have too commonly assumed that industry and agriculture are separate parts of our economy, Professor Theodore W. Schultz of the Department of Agricultural Economics, University of Chicago, has written a book, AGRICULTURE IN AN UNSTABLE ECONOMY,

[1] Schultz, Theodore W.: AGRICULTURE IN AN UNSTABLE ECONOMY. New York and London, McGraw-Hill Book Company, Inc., 1945, 299 pp. $2.75.

in which the interdependence of agriculture and industry is repeatedly emphasized. He considers the agricultural problem as it stems from the interrelationship between agriculture and the rest of our economy and offers concrete suggestions for a national agricultural policy.

According to the author, low earnings and instability of income among farm people is due to the unequal growth of supply and demand for farm products. Contrary to what Malthus and Mills predicted, the supply of farm products has outdistanced the demand for them and this has culminated in a chronically depressed state for agriculture. Demand has increased at a diminished rate, due primarily to the decreasing rate of growth of the populations which provide a market for American agriculture, and to the low income elasticity of farm products. The supply, on the other hand, has grown faster than demand because of great technological advances, increase in capital, and development of new land.

The forces that are bringing about this disequilibrium were temporarily interrupted during the two World Wars but gained momentum with the end of each war. Since, the author contends, our economic system lacks the balancing mechanism necessary to halt this trend, we must evolve a national agricultural policy aimed at correcting the maladjustments.

The author sets forth a long and a short-term policy for correcting the imbalances inflicted on agriculture by forces in the rest of the economy. His long-term policy is concerned with moving the excess resources, primarily labor, out of agriculture in order "to equate the forces and counterforces affecting the supply and demand of farm products" (p. 82). This process has already been taking place. During 1920-1939 ten million people migrated from farms to nonfarm occupations. Large as this number appears, it was only a little more than the natural increase of the farm population (8.7 millions) and was not sufficient to raise farm incomes to a level with those outside of agriculture (p. 98). The average net income per worker engaged in agriculture was 53 per cent of that of the industrial worker in 1920, and only 42 per cent in 1939 (p. 98). This percentage rose to only 62 per cent by 1944 even though the farm population is estimated to have decreased by about five millions (or by over 15 per cent) between 1940 and 1944. The author cites these figures to show that a mass migration out of agriculture is necessary to avoid chronic depression in agriculture. He claims that this withdrawal of labor will not be

automatically induced by falling farm prices. In fact, since World War I, rural-urban migration tended to be lightest during periods of falling farm prices because these were periods of dwindling job opportunities in cities. Hence, as a primary goal of national agricultural policy, he urges constant expansion of nonagricultural industries at a rate higher than the expansion of agriculture (p. 202).

As for "short-term" policy, the author suggests three immediate objectives: (1) to lessen the instability of farm income; (2) to adjust agricultural production; and (3) to establish a positive pricing policy. Toward accomplishing the first of these aims he suggests several forms of crop insurance to reduce income instability caused by production variability, and compensatory payments to diminish income instability caused by fluctuation in demand. His payment proposal is interesting and can bear closer inspection. "There are two requisites to the use of compensatory payment.... They must be undertaken by the government only in the event of a business depression—if they are to be counter cyclical; and they must be so paid that they do not cause a disturbance in the trade and production of farm products" (p. 222). Professor Schultz proposes to pick a "predepression price" for farm products, *i.e.*, the market price just prior to the time when a depression in the nonagricultural sectors is deemed to have set in, and to pay the farmer all, or a large part, of the difference between this price and the current depression market price. Some question may arise here as to whether an accurate indicator of economic activity can be set up and whether the selection of this "predepression price" is administratively feasible. The author contends that this plan, with all its difficulties, is superior to other proposed alternatives.

The author also holds that prices could be made the means for adjusting agricultural production, and for better allocation of resources. He thinks that prices should not be set up as goals to be achieved, as they are in present legislation; nor should they be tied to some long-past situation such as the parity prices based upon 1910-1914 levels. The author gives three aims for a future price policy for agriculture: (1) stabilize general level of prices because "farmers are peculiarly vulnerable to price movements"; (2) close the gap between domestic and foreign prices; and (3) set up a system of "forward prices."

As for the latter, the author advocates conversion of the "support prices" (established during the war) into "forward prices" (p. 265). "Such forward prices should present each farmer, as he proceeds with

his production operations, with a schedule of relative prices for at least one production period ahead, considerably more dependable than heretofore. As this is accomplished, it would increase the ability of farmers to allocate and use the resources at their disposal much more efficiently. It would also reduce very appreciably the price uncertainty burdening American farmers" (p. 271).

This price regulation proposal may bring doubt to some students' minds about the future role of competition in agriculture. At least in principle, however, most will agree that "the need is great for policies serving American agriculture that are consistent and integrated with our other national policies."

PRISCILLA M. AFFEL

INDEX

TO TITLES OF ARTICLES AND AUTHORS IN THE MILBANK MEMORIAL FUND QUARTERLY

VOLUME XXIV • 1946